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EXPLORING ASYMMETRIC ROLES IN MIXED-ABILITY GAMING

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Resumo

A grande maioria dos jogos — jogos digitais e jogos de mesa — são desenhados para jogadores com um conjunto padrão de habilidades. Existem exemplos reconhecíveis de jogos que acomodam uma ampla gama de necessidades, na procura de uma acessibilidade universal, mas estes são uma exceção à regra. Na realidade, as minorias com alguma forma de deficiência são barradas do que a maioria das pessoas joga. Uma população que é normalmente desconsiderada é aquela com deficiência visual, visto que a grande maioria dos jogos implica uma interpretação e interação visual.

O problema não é apenas uma falta de vontade ou desprezo da indústria de jogos em seguir diretrizes de acessibilidade. Os desenvolvedores geralmente não têm formas de acomodar necessidades diferentes sem limitar a jogabilidade e a apresentação, o que pode resultar em algo que, no final não satisfaz nenhum jogador. Mesmo que o acesso à informação seja garantido, a interação e o desafio que um jogo apresenta podem não ser interessantes e divertidos para todos os jogadores. Um jogo acessível para todos não é necessariamente uma experiência agradável para todos. De facto, jogos mixed-ability ainda parecem uma realidade remota, apesar de investigação anterior no assunto.

O impacto que uma deficiência tem no desenho de jogos está relativamente bem documentado. Contudo, é urgente encontrar formas de incluir diferentes necessidades desde o início do processo de desenho. Como tal, é importante compreender os diferentes perfis de jogadores, os seus hábitos e preferências, inclusivamente em relação a experiências em que jogam com outras pessoas. A falta de entendimento neste assunto era aparente e demos um primeiro passo ao coletar e interpretar experiências de jogo entre pessoas com diferentes níveis de visão. Conduzimos um estudo preliminar, que incluiu entrevistas individuais com 10 adultos cegos; duas entrevistas em grupo com menores com deficiência visual; 140 respostas a um primeiro questionário on-line, dirigido a pessoas com deficiências visuais; e 17 respostas a um segundo questionário on-line, dirigido a pessoas normovisuais que tinham experiências passadas a jogar com alguém com deficiência visual.

Neste estudo, verificámos que, apesar de uma variedade considerável de jogos acessíveis, as possibilidades de jogar com pessoas com um nível de visão diferente, como familiares e amigos são escassas e não são ideais. Em vários casos, pessoas com deficiência visual são excluídas de jogos em grupo. Experiências mixed-ability foram

associadas a uma experiência menos divertida ou injusta para uma das partes. Foram dadas diversas razões para isto. Recorrente foi a questão que os jogos acessíveis (nomeadamente áudio jogos e jogos baseados em texto) não são apelativos para jogadores normovisuais. Por outro lado, jogos com interação visual são inacessíveis ou induzem uma competição injusta. Os jogos seguem uma abordagem centrada no utilizador e, conscientemente ou inconscientemente, estes são desenhados para um único conjunto de habilidades. Esta realidade dificulta a interseção de hábitos de jogos entre jogadores com diferentes habilidades, levando à segregação de comunidades, situações de exclusão em grupos de amigos e mesmo no seio da família.

No contexto da situação que encontrámos, discutimos as implicações e oportunidades de desenho para jogos inclusivos, mais especificamente para contextos mixed-ability. A discussão passou pelos seguintes pontos principais: 1) a necessidade de se considerar um *targeting* mais amplo na concepção de jogos acessíveis e mesmo em jogos desenhados especificamente para pessoas com deficiências; 2) o potencial da tecnologia digital em jogos analógicos e benefícios para pessoas com deficiências visuais; 3) a inacessibilidade das plataformas de jogos, bem como a falta de informações de acessibilidade quanto aos jogos disponíveis nessas plataformas (inclusivamente na forma como estes jogos são divulgados ao público); 4) a oportunidade de desenhar jogos com jogabilidade assíncrona para contextos mixed-ability, no sentido de desenhar jogos que podem ser desfrutados ao ritmo de cada jogador; 5) a oportunidade de explorar formas alternativas de progredir num jogo, como mecânicas que reduzem alguma interação para permitir a experiência (por exemplo, formas de auto-navegação); 6) por fim, a abordagem que exploramos no seguimento deste trabalho, que reside na oportunidade de explorar uma jogabilidade assimétrica no sentido de desenhar e entrelaçar diferentes interações e desafios adequados às necessidades e preferências de cada jogador.

Assim, concebemos e instanciámos papéis assimétricos com tarefas baseadas em habilidades como forma de incluir mais que um estereótipo na jogabilidade. Envolvemos a assimetria numa colaboração interdependente, fomentando complementaridade e sinergias entre tarefas com o objetivo de incentivar o jogo social e o eventual sentimento de inclusão. Em suma, em vez de procurar uma única jogabilidade cativante para diferentes jogadores com habilidades e preferências diferentes, procurámos explorar o cruzamento de diferentes jogabilidades como uma opção de design na obtenção de um jogo agradável para ambos. Desenhámos e desenvolvemos dois jogos colaborativos prova-de-conceito que exploram papéis assimétricos interdependentes com desafios mapeados para diferentes habilidades (visuais, num papel, e auditivas no outro). Para reforçar a interdependência entre jogadores, nos jogos existe apenas um ”personagem”que navega pelo cenário, mas ambos os jogadores atuam e são essenciais para que este cumpra os objetivos. Um jogador atua através de uma interação apenas visual e o outro através de uma interface auditiva.

No primeiro jogo, "*Resgate: Sob Pressão*", o jogador com interação visual consegue mover e tem controlo direto sobre a personagem e o jogador com interação auditiva tem uma percepção global do cenário. Neste jogo, os dois jogadores controlam um submarino, sendo que um controla o sonar (desafio auditivo) e o outro "conduz"o submarino e utiliza variadas ferramentas (desafio visual). No segundo jogo, "*Resgate: Urgência Aérea*", invertemos o mapeamento de papéis para habilidades. Um jogador pilota um avião de resgate através de uma interação apenas auditiva e o segundo é um controlador de tráfego aéreo, com uma tarefa apenas visual. Inspirámo-nos no facto de que os pilotos de aviões normalmente não voam com base em informações visuais e, em vez disso, têm que confiar nos instrumentos de navegação e instruções dos controladores de tráfego aéreo.

Num estudo remoto com 13 pares mixed-visual-ability, avaliámos o impacto dos jogos e papéis nas percepções de competência, autonomia e contentamento geral. Os jogos proporcionaram uma experiência divertida e desafiante, na qual as diferenças nas habilidades não foram restringentes. Os resultados evidenciam que experiências desenhadas para serem desiguais podem dar origem a uma experiência conjunta em que existe equidade.

Esta tese tem como principais contribuições:

- Uma caracterização de experiências multijogador de pessoas com deficiência visual, relativamente a jogos analógicos e digitais. Como objetivo inicial, procurámos um conhecimento mais abrangente sobre os hábitos, opinião e perspectivas futuras de pessoas cegas e com baixa visão em relação ao ato de jogar e, acima de tudo, de jogar com os outros. Encontrámos implicações e oportunidades para o desenho de jogos para contextos mixed-ability.

- Uma abordagem conceptual focada na criação de experiências de jogo que podem cativar pessoas com diferentes perfis, projetando papéis assimétricos com desafios baseados em habilidades, envolvidos numa colaboração interdependente.

- Duas instâncias prova-de-conceito da abordagem. Projetámos e desenvolvemos dois protótipos de jogos multiplayer, visando pares com habilidades visuais mistas.

- Validação da abordagem no contexto de grupos com habilidades visuais mistas. Avaliámos o impacto na perceção de competência, autonomia e contentamento geral, e descrevemos as percepções que surgiram.

Acreditamos, e neste trabalho de dissertação torna-se patente, que a acessibilidade não deve ser um esforço *a posteriori* para adaptar algo às necessidades das pessoas com deficiência, o que parece ser recorrente também no campo da acessibilidade em jogos. Defendemos que esta deve consistir em encontrar formas de incluir essas diferentes necessidades desde o início do processo conceptual e de desenho. Torna-se urgente

pensar na população como a amálgama complexa e diversa que é e encontrar formas de fechar os vales que dividem as diferentes comunidades, seja pelas habilidades, idade ou cultura. Trabalho neste sentido é essencial para combater a percepção de que os jogos (e qualquer conteúdo) têm que ser projetados para um único jogador estereotipado sem deficiências, aproximando-nos de um mundo onde as diferenças existem e são orgulhosamente abraçadas no desenho.

Palavras-chave: Jogos, Acessibilidade, Deficiência Visual, Mixed-ability, Assimetria

Abstract

Noticeably, the majority of mainstream games — digital games and tabletop games — are still designed for players with a standard set of abilities. As such, people with some form of disability, often face insurmountable challenges to play mainstream games or are limited to play games specifically designed for them. By conducting an initial study, we share multiplayer gaming experiences of people with visual impairments collected from interviews with 10 adults and 10 minors, and 140 responses to an online survey. We include the perspectives of 17 sighted people who play with someone who has a visual impairment, collected in a second online survey. We found that people with visual impairments are playing diverse games, but face limitations in playing with others who have different visual abilities. What stood out is the lack of intersection in gaming opportunities, and consequently, in habits and interests of people with different visual abilities. In this study, we highlight barriers associated with these experiences beyond inaccessibility issues and discuss implications and opportunities for the design of mixed-ability gaming. As expected, we found a worrying absence of games that cater to different abilities. In this context, we explored ability-based asymmetric roles as a design approach to create engaging and challenging mixed-ability play. We designed and developed two collaborative testbed games exploring asymmetric interdependent roles. In a remote study with 13 mixed-visual-ability pairs we assessed how roles affected perceptions of engagement, competence, and autonomy, using a mixed-methods approach. The games provided an engaging and challenging experience, in which differences in visual ability were not limiting. Our results underline how experiences unequal by design can give rise to an equitable joint experience.

Keywords: Gaming, Accessibility, Visual Impairments, Mixed-ability, Asymmetry

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Chapter 1

Introduction

It is estimated that around 15% of the global population experience some form of disability [65]. Today, common barriers, such as inaccessible physical environments, transportation and non-adapted means of communication are identified, combated by regulation and addressed by existing guidelines for different branches such as architecture and technology. Living conditions have improved and are improving towards the satisfaction of needs and inclusion. Discriminatory prejudice, social isolation and stigma are fought in health, education and employment through decades of work by the United Nations and diverse organizations, summits and other initiatives for human rights and sustainable development. However, leisure, the mere act of pasting time and having fun with family and friends is also restricted [42, 46, 55, 70, 100].

1.1 Motivation

Games are an efficient way of bringing two or more people together through rich interaction triggered by challenging goals and immersive settings. The majority of both tabletop and digital games imply the simultaneous use of a set of abilities throughout the gameplay —- such as a continuous visual interpretation and interaction with the game elements or the identification of a sound that marks a specific event. These abilities are normally assumed as granted in the development of new games, creating a barrier that can discourage people with disabilities from gaining or maintaining interest in playing with others and even in playing at all.

Typically, the efforts on making accessible digital games involve adapting already materialized ideas that in their genesis do not take into account disabilities —- e.g., audio-only games adaptations of strongly-visual installments like first-person shooter Doom[1], made accessible to blind people; versions of games like Frogger[2] and Mini

[1]Shades of Doom. `http://www.gmagames.com/sod.html` (Last visited on September 16th, 2020)

[2]One-Switch Frogger. `http://web.archive.org/web/20120106225734/http://www.havsoft.co.uk/one%20switch.htm` (Last visited on September 16th, 2020)

Golf[3] designed for motor impaired people, usually played through a switch controller or voice interface; universally-accessible redesigns of traditional games like Chess [34] and Tic-Tac-Toe [66].

These efforts are truly important, however, in the midst of this conversion, the core gameplay may significantly change, the essence of the game can be lost and the game can turn out to be no fun for anyone. This is critical in the process of adapting games for people with visual impairments, since most games rely on visual feedback. This implies that, in most cases a substantial redesign is needed to ensure the player is able to perceive the information, determine the correct action and provide input.

Furthermore, there are game patterns and specific mechanics that do not endure as challenging, exciting or fun when certain conditions limit the experience. For example, as much as driving and first-person shooter gameplays have been efficiently adapted for blind people in previous studies [31, 78, 94], there is a strong dependency that naturally bonds these experiences to visual interaction. In such cases, adaptation becomes especially difficult and likely insufficient in conserving the aim of the challenge posed, but also the reason for the thrill. We recognize the motivation in providing empowering experiences that allow people to do tasks in a virtual environment that they usually could not do in real life, such as driving or shooting in the case of people with severe visual impairments. However, we argue that such experiences, in a hedonic context, cannot be a mere readjustment of traditional implementations — their interest and replayability depend on novel solutions and clever game design.

New games usually target a stereotypical player, with a defined set of abilites. Therefore, most of the patterns found in games are not suited to people with disabilities. Some gameplay styles naturally unveil as opportune —- e.g., text adventure (also known as interactive fiction) genre is often totally accessible to blind people, through the use of a screen reader as well as fighting games, thanks to the profusion of auditory feedback inherent to the gameplay [4]. Unfortunately, ideas for new accessible games are rarely taken from scratch and are hardly ever motivated to create a experience that can be enjoyed together by players with different abilities. Finding ways in game development to fulfill the needs of a specific audience with determined abilities is not easy, but finding ways to bring together and engage mixed-ability groups in a game can be a tough challenge. Prior research explored different design choices to achieve a pleasurable gameplay for mixed-ability groups [30, 36, 44, 74]. We argue that the same gameplay, however accessible could generally never be engaging for all players in such group.

In gaming context, symmetry means that players have the same goal and can achieve it by accomplishing the same tasks through the same possible actions. In mixed-ability play, symmetry may unravel as a barrier. For instance, the main strategy when designing

[3]Tiny Town Golf. `http://www.oneswitch.org.uk/art.php?id=112` (Last visited on September 16th, 2020)

games to be played by both blind and sighted people is to replace visuals with audio. This solution is typically implemented in two ways, each leading to one of two undesirable extreme outcomes. The *equitable approach* would remove entirely the visual stimuli, resulting in an audio-only game — priority is ensuring that both players are on the *same ground*. Yet, it also potentiates a *less appealing experience by players without disabilities*, ultimately discouraging them to keep playing. Alternatively, visual and auditory stimuli could be kept within the game, admittedly supplying richer output and more input possibilities to the sighted players. This could lead to a *limiting experience by players with disabilities*, inducing unfair competition or vain cooperation.

The main motivation of this thesis was to explore the use of ability-based asymmetric roles in the development of new games that can be enjoyed by players with different abilities. In our approach, we intertwine roles into an interdependent collaborative gameplay, fomenting complementarity and synergies between tasks and challenges [71]. The aim of the approach is to cater for different abilities and to ensure that each player can properly contribute to a common goal, by assigning a task that is mapped to player's abilities — e.g., a player with a visual impairment can contribute in diverse kinds of challenge, if these are not dependent of the ability to see. In short, instead of looking for a single gameplay that can be experienced by players with different abilities, we sought to explore the entwining of different gameplays as a potentially effective design choice to achieve a pleasurable game to both — players should be able to play the roles that best suit their abilities, regardless of their limitations. We focused our research on multiplayer experiences between sighted players and people with visual impairments, but we aimed to find and discuss insights that could inform inclusive game design in the broader range of mixed-ability contexts.

1.2 Approaches to Disability Inclusion

With the end of the World War II emerges the internationalization of human rights and with that, early practices of accessibility. Parking lots, public transportation, classrooms, laboratories, libraries, cafeterias begin to be modified, meeting the needs of people with disabilities [1, 22]. Later, in the 1980's, worldwide campaigns argue that is not enough to readjust spaces. Accessible design is demanded, arguing that barriers should not be inserted at all and promoting an accessible physical environment for everyone [22, 88]. This is the foundation of the universal design concept, which advocates a vision based on human diversity and broadens the concept of accessibility to encompass architectural, communicational and attitudinal dimensions [88].

For its part, accessible computing followed these trends. At the origin of assistive technologies is the idea of restoring autonomy of people with disabilities [54]. Some of them are widely used today, such as screen readers for people with visual impairments,

virtual keyboards for people with motor impairments and speech synthesizers for people with speech impairments. These play a very important role in the daily lives of people. However, in its essence, this concept assumes that systems are immutable and additional components are inserted between the user and the system, as a way to fit the first to the second. These solutions promote equal but separate access, which ultimately may stigmatize the user [39]. Similarly to what happened in architecture, the concept of universal design becomes prominent in accessible computing [53, 76, 81, 82, 91] — just as physical spaces should be originally designed to accommodate different people's needs, regardless of gender, age, culture and abilities, so should systems be usable by all, without the need for specialized add-ons or devices. Direct access (i.e. system is accessible to the user) is pursued to the detriment of indirect access (i.e. system is compatible with assistive technology).

In 2011, Wobbrock *et al.* [96] introduce the concept of ability-based design. The main principles of this perspective are presented as a replacing set of questions to model accessible computing. Importantly, in this approach, design process is based on "what *can* a person do?", emphasizing the focus on abilities, not on limitations. It pursues universal and inclusive usability and places the responsibility for adaptation in the system — software should be designed in a way that commodity (low-cost and widely available) input devices like mice, touchpads and keyboards are equally effective, when used by people with and without disabilities. To achieve this, the system must be aware of user performance, and interfaces should be user-adaptable — universally usable. However, it is pointed out that universal approaches often search for "what can everyone do?", while ability-based takes it from a design-for-one perspective, that asks "what can *you* do?".

More recently, Bennett *et al.* [8] point out the negative side of assuming people's independence as the goal of accessibility, being that everyone is actually dependent. From this perspective, the use of assistive devices can provide full autonomy to the user, but can also picture users as "*vulnerable or incapable*". The advantages of acknowledging the essential interdependence existing between all humans are highlighted. Authors argue that an interdependence frame established in personal relationships may emphasize contributions from people with disabilities and defy traditional hierarchies that rank abilities. Researchers conclude the search for independence and interdependence could coexist as two simultaneous goals in assistive technology research and design.

These different perspectives and conceptual progress regarding inclusion and accessible computing is key when framing the approach we explore: an asymmetric gameplay in which each player performs ability-based tasks, contributing to a common goal — an interdependent group of players, as in most collaborative games, helping each other to succeed.

1.3 Contributions

Our main contributions with this dissertation are:

- A characterization of multiplayer experiences of people with visual impairments, regarding both analog and digital gaming. As a start goal, we sought to learn more about the background, current opinion and future perspectives of blind and low vision people on playing, playing with others, and playing collaboratively. We found limitations and opportunities in game design for mixed-ability contexts.
- A conceptual approach focused on creating gaming experiences that cater for different abilities by designing asymmetric roles with ability-based challenges involved in interdependent collaboration.
- Two proof-of-concept instances of the approach. We designed and developed two multiplayer game prototypes, targeting mixed-visual-ability pairs. Games are available[4].
- Validation of the approach with 13 mixed-visual-ability pairs. User perceptions revealed the games offered engaging and challenging experiences, in which the difference in abilities was not a limiting factor. Assuming an explicit asymmetry on the gameplay made both parties felt included and equal.

1.4 Publications

The results of the first study we conducted were published in an international peer-reviewed conference:

David Gonçalves, André Rodrigues, and Tiago Guerreiro. 2020. Playing With Others: Depicting Multiplayer Gaming Experiences of People With Visual Impairments. In *The 22nd International ACM SIGACCESS Conference on Computers and Accessibility* (ASSETS '20), October 26–28, 2020, Virtual Event, Greece. ACM, New York, NY, USA, 12 pages.

The second phase of the work, which includes the description of the approach, game design process and the user study that followed, was written into an article and submitted to the *CHI 2021* conference:

David Gonçalves, André Rodrigues, and Tiago Guerreiro. 2021. Exploring Asymmetric Roles in Mixed-Ability Gaming. [under review]

[4]Games Repository: `https://osf.io/2ng3y/?view_only=5ffd259a507b42af946d1468240613bf`

1.5 Document's Structure

This document is organized as follows:

- **Chapter 2 – Related Work**. We provide an overview of games accessible to people with visual impairments — specially designed for this target audience, adapted versions of other games and games with built-in accessibility — and highlight issues, relevant approaches and examples of clever design. We look into past research on mixed-ability group play and asymmetric games. Lastly, we introduce frameworks that were previously used in game development and relate them to our work.

- **Chapter 3 – Delving Into Mixed-Ability Gaming**. This chapter includes the reports resulting from a first characterization study conducted during November and December, in which we probe mixed-visual-ability gaming experiences. The study comprised individual interviews with 10 blind adults; two group interviews with 10 visually impaired minors; one online questionnaire answered by 140 respondents with visual impairments; and one online questionnaire answered by 17 sighted respondents who had past experiences playing with someone with visual impairments. We present design limitations and opportunities derived from this characterization.

- **Chapter 4 – Instantiating Asymmetric Ability-Based Roles**. Recognizing that mixed-ability digital play remains rare and restricted, we sought to explore a different approach to game design that caters for different abilities. We created game prototypes in which there is a complete asymmetry in the gameplay based on abilities (i.e. visual and auditory). In this chapter, we further detail the approach and explain the design process of these games, undertaken from January to July.

- **Chapter 5 – Inspecting Asymmetry in Mixed-Ability Contexts**. We conducted a user study with 13 mixed-visual-ability pairs, from July to September. Each pair tried both games and had the opportunity to share their perspectives through online questionnaires. We assessed the impact of the experience on perceived engagement, competence and autonomy. We present the results and highlight the potential of the approach for these contexts.

- **Chapter 6 – Conclusions** Our final thoughts on the work and prospects for forthcoming work.

Chapter 2

Related Work

In recent years, the gaming industry has made significant efforts towards more accessible gaming. Notably, the 2015 PS4 update included many accessibility features such as text-to-speech and resizable fonts. Likewise, Microsoft debuted the Copilot[1] feature for Xbox in 2017 and the Xbox Adaptative Controller[2] in 2018. Game developer company *Electronic Arts* has recently launched a portal website containing guides to aid people with visual impairments, information on accessibility features and forums for technical support[3]. *Ubisoft Entertainment SA* provides audio descriptions for the trailers of its most recent released games [69].

Game accessibility guidelines have been published and disseminated in different ways on several occasions [12, 33, 37, 58]. Some of these guidelines are often met by the game industry, notably colorblind-friendly color palettes and the inclusion of subtitles [68]. Still, it is noticeable that almost all mainstream games are completely inaccessible to people with severe impairments, such as the inability to see or to interact with the hands. The problem is certainly not just indifference on the part of game industry. In many cases, developers have no ways to accommodate such conditions, without severely limiting the gameplay and presentation of the game, which could result in something that would not really satisfy any player. Also, a game can be accessible for all but not necessarily enjoyable for all. Whether games for educational, health or purely hedonic purposes — as Archambault *et al.* mention, "*accessible games must still be games*" [5] and finding techniques that give access to all the information needed is insufficient. The result must be entertaining and retain interest.

In most cases a substantial redesign is required. *Blackbox*[4], designed by developer Ryan McLeod and sound designer Gus Callahan, is an awarded iOS puzzle game fully accessible to blind people. Although minimalist visuals provided the main output on first versions, all puzzles were redesigned to be playable through alternative sonic interfaces, Voice Over and vibration. This is a remarkable example, because not only is the input efficiently ensured in image and audio form, but also input is delivered in completely out-of-the-box ways — turning the device upside down, shaking it, blowing into the

[1]Copilot on Xbox One. `https://beta.support.xbox.com/help/account-profile/accessibility/copilot` (Last visited on September 16th, 2020)

[2]Xbox Adaptive Controller. `https://www.xbox.com/en-US/accessories/controllers/xbox-adaptive-controller` (Last visited on September 16th, 2020)

[3]EA Accessibility Portal. `https://www.ea.com/able` (Last visited on September 15th, 2020)

[4]Blackbox. `https://www.blackboxpuzzles.com` (Last visited on September 15th, 2020)

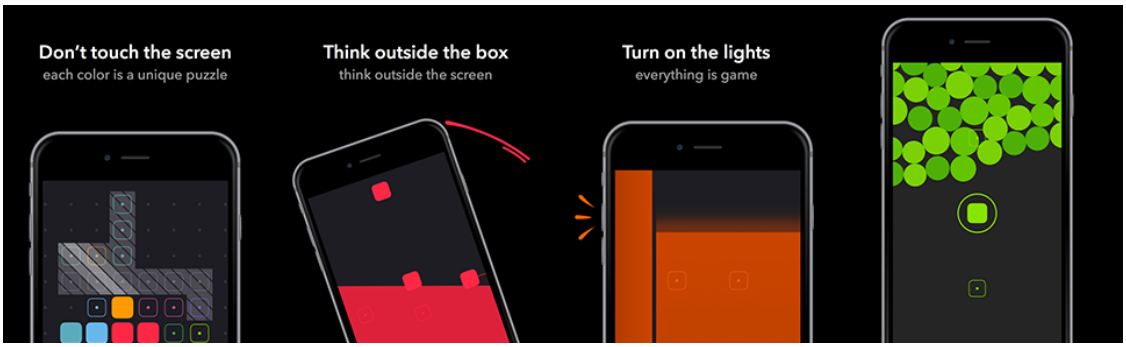

Figure 2.1: *Blackbox* forces the player to be creative and find alternative ways to interact with the device as a way to solve the diverse puzzles. It is totally accessible to blind people through auditory clues and voice-over descriptions.

microphone or turning up the volume are just some examples. More recently, *The Last of Us Part II*[5], a 2020 top-selling game by Naughty Dog, offers more than 60 accessibility options to players [80]. Notably, the game includes an audio-based reliable rendition of the gameplay that allows someone to play with no visuals at all [80]. The game provides tremendous flexibility allowing players to tweak various aspects of the gameplay and find the most accessible and engaging way to play.

The gameplay experience model proposed by Laura and Frans [52] describes immersion when playing as a result of three main factors — sensory stimulation, narrative and challenge. Regarding gameplay with no visual component, sensory immersion is limited. Accordingly, in many accessible games for blind people, particular attention is paid to narrative and storytelling, as well as the application of alternative ways of input/output, techniques and patterns when designing game mechanics. The way sound (and haptic feedback, when it is available) is used and its fidelity becomes essential. Moreover, language can be a major barrier. In most video games, visual cues can be sufficient to reach universal understanding (among sighted players). However, it is a challenge to illustrate instructions through audio, without resorting to speech, although it has been explored in the past [27].

Below we provide an overview of games specially developed for people with visual impairments as well as games designed to be played by people with different abilities and scrutinize the commonplaces and innovative solutions that come up with these. We then present a selection of games with asymmetric roles and analyze examples in the mainstream scenario and mixed-ability environments. Lastly, we introduce efforts on game studies pertinent to this work, namely structural models that examine game content and different frameworks for game design and evaluation.

2.1 Accessible games to people with visual impairments

A big diversity of game types, genres and themes can emerge from sound-only interaction. Notably, the web site audiogames.net — i.e. the biggest repository of sound-based games

[5]The Last of Us Part II. `https://www.playstation.com/pt-pt/games/the-last-of-us-part-ii-ps4/` (Last visited on September 15th, 2020)

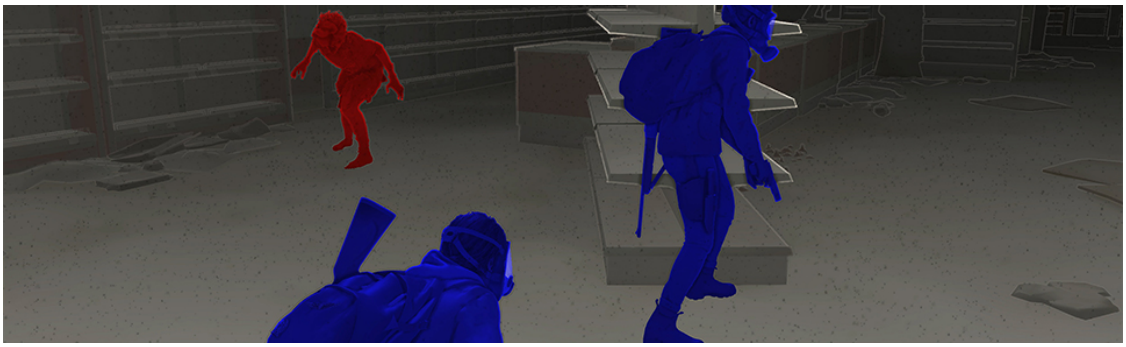

Figure 2.2: *The Last of Us Part II* is regarded as one of the most accessible games ever. It includes features such as high-contrast visuals, combat and navigation assist modes, audio cues implemented for all relevant elements and speech for every piece of text on the screen.

and now mostly run by blind gamers — presents a list of games that grows frequently with new installments and updated versions, and proves to be significantly diverse. Currently, there are 756 games (as of October 18th, 2020) categorized into almost 30 different genres in this list, excluding game compilations and miscellaneous tools such as interpreters and software to create new audio games [Table 2.1]. Some of these games, genres and gameplay patterns eventually stood out over time.

The series of games from *Somethin' Else*[6][7][8][9] consists of four audio-only single experiences for Apple iOS devices. The feeling of immersion is one of the games' strengths, being highly story-driven (especially the first three games), set in a survival horror scenario with a very simple intuitive gameplay —- screen tapping and the use of the accelerometer to correctly direct the aim (alternatively swipe or tilt-based controls are also on offer). The latest game released by the developer company, *Audio Defence - Zombie Arena* made the shift to a more fast-paced gameplay rather than strong narrative. In none of these games, the character played is really blind, but the lack of graphics is explained by the story as a consequence of the world total darkness. Despite the popularity of the games, they were before criticized for their depiction of blindness as "*terrifying*", "*as a problem to overcome*" [18].

In the cross-platform game *A Blind Legend*[10], players control a brave blind knight. Gameplay is more combat-oriented, settled through simple controls and again there are no graphics. Navigation is ensured with binaural 3D sound and audio cues as voices, footsteps, rain, and *medievalish* ambient noises such as the trot of the horses and the hammering of blacksmiths. The game unveils also as quite immersive, supported by an

[6]Papa Sangre. `https://www.pocketgamer.com/games/015146/papa-sangre/` (Last visited on September 15th, 2020)

[7]Papa Sangre II. `https://www.pocketgamer.com/games/022012/papa-sangre-ii/` (Last visited on September 15th, 2020)

[8]Audio Defence - Zombie Arena. `https://www.pocketgamer.com/games/023023/audio-defence-zombie-arena/` (Last visited on September 15th, 2020)

[9]The Nightjar. `https://www.pocketgamer.com/games/015661/the-nightjar/` (Last visited on September 15th, 2020)

[10]A Blind Legend. `http://www.ablindlegend.com/en/home-2/` (Last visited on September 15th, 2020)

Figure 2.3: In *Papa Sangre 2*, gameplay is based on a pair of buttons to move and another pair to interact. Navigation is ensured by rotating/tilting the device or with swipe gestures. A separate UI is dedicated to VoiceOver users, which works simultaneously with the sound engine.

interesting narrative established through dialogue and cut scenes that introduce or conclude exploration/combat segments. *Blindscape*[11] and *Dark Passenger*[12] are similar initiatives, based on simplistic interaction, where the story told turns out to be the main focus. Particularly in this genre, there are examples of high-quality immersive sound and voice acting. Gameplay can potentially be repetitive as the mechanics are not meant to be necessarily challenging or engaging, but only as a way to progress in the narrative.

Text-based adventure games, namely IF (interactive fiction) were expressively popular during the late 70s and 80s, remaining popular among blind players until today. Usually, these games follow a *choose-your-own-adventure* format, in which players' decisions dictate the development of the story[13] [14]. Ronny Andrande *et al.* [4] established the ability to affect the game narrative as a critical factor that attracted blind people to gaming — in the words of a blind interviewee "*I don't even need a massive world, or anything like that, just something that feels important, like I'm doing something*". This feeling of agency is indeed evident in IF games.

Multi-User Dungeons (MUDs) expands the concept of text-based adventures to the multiplayer horizon and allows players to interact with other players, items and characters by typing predefined commands. Worlds are often rich in fantasy and immersive, which inspire players to explore. Role-playing is typically allied with these concepts and is shown to be appreciated by blind players [4]. Indeed, a significant collection of role-playing games (RPG) and massively multiplayer online role-playing games (MMORPG) is found at audiogames.net [Table 2.1]. The majority of these are

[11] Blindscape. `http://www.blindscapegame.com/` (Last visited on September 15th, 2020)

[12] Dark Passenger. `https://store.steampowered.com/app/611140/Dark_Passenger/` (Last visited on September 15th, 2020)

[13] Grail to the Thief. `https://store.steampowered.com/app/373140/Grail_to_the_Thief/` (Last visited on September 15th, 2020)

[14] Choose your own CaveVenture. `http://madzab.itch.io/choose-your-own-caveventure` (Last visited on September 15th, 2020)

accessible also due to their text-based nature, making interaction entirely dependent on screen reading. These games do not usually come with a built-in narration mode, which in one hand, may ultimately break the immersion due to the emotionless, robotic screen reading, on the other, may be more practical and intelligible. This type of interaction also implies a slow-paced gameplay, often based on strategic management, crafting and trading of resources and/or time-unrestricted turn-based combat mechanics. *Manamon*[15] and its sequel[16], by *VGStorm* is a role-playing audio game that recreates the famous Pokémon games. Instead of Pokémons, illustrated by bizarre and fun looks, the player catches and trains Manamons, each with a distinct sound and description associated. Players can collect various items and engage in turn-based battles with other trainers (controlled by AI or online players), as in the original game. This type of strategy-based RPG games is commonly known and played [4].

Figure 2.4: Core Exiles is a popular browser-based sci-fi MMORPG. Gameplay is ensured mainly by text although illustrations are widely used.

Previous work has explored alternative navigation systems in games, namely audio, text-based and haptic interfaces [6, 23, 57, 73, 75, 85, 86, 94, 95]. For instance, in *AudioQuake* [6], an adaptation of the popular *Quake*[17], researchers use earcons to facilitate in-game interaction. In some audio-based games there's an analogy with real-life navigation systems, such as compass and sonar like features [3, 94].

Ossmann *et al.* [66] suggest a categorisation of audio games and compare it to the common categorisation of video games. Regarding strategy games, map manipulation is referred as one of the main mechanics of strategic gameplay often absent from audio games, quite simply because it is usually vision-dependent. They argue that resource management and simulation aspects gain prominence to the detriment of tactical placement. From military settings[18] to the ruling of a village invaded by dragons[19] and

[15]Manamon. `https://www.vgstorm.com/manamon.php` (Last visited on September 15th, 2020)

[16]Manamon 2: The Eternal Requiem. `http://www.vgstorm.com/manamon2.php` (Last visited on September 15th, 2020)

[17]QUAKE. `https://store.steampowered.com/app/2310/QUAKE/` (Last visited on October 23rd, 2020)

[18]Time of conflict. `https://audiogames.net/db.php?action=view&id=Time%20of%20conflict` (Last visited on September 15th, 2020)

[19]Dragon Village. `https://audiogames.net/db.php?action=view&id=Dragon%20village` (Last visited on September 15th, 2020)

Table 2.1: Categorization of the 756 games (except compilations and miscellaneous tools) in audiogames.net (as of October 18th, 2020) according to the specified genre on the list. "Space Invaders Games" (23) are considered as "Arcade"; "Audio Adventure" (13) and "First Person Adventure" (16) are considered as "Adventure"; "First Person Shooter (FPS)" (7) and "Top-Down Shooter" (5) are considered as "Shooter"; "Japanese" (14), "Adult Games XXX" (10), "Educational" (12), "Social Game Hubs" (6) and "None" (6) are all considered as "Other".

Genre	Example	N	Genre	Example	N
Adventure	A Blind Legend	53	**Side Scroller**	Tarzan Junior	26
IF	Code 7	39	**Shooter**	Swamp	12
Gamebooks	Timecrest	23	**Racing**	Topspeed 3	20
RPG	A Hero's Call	48	**Sports**	Hattrick	24
MMORPG	Core Exiles	59	**Rhythm**	Sequence Storm	10
MUD	Alter Aeon	20	**Simulation**	Eurofly	13
Strategy	Castaways	47	**Card**	Blindfold Blackjack	27
Incremental	Crafting Kingdom	22	**Traditional**	Accessible Domino	49
Puzzle	Blackbox	57	**Trivia**	Trivia	11
Action	Blind Gladiator	20	**Word**	Wordfinder	28
Arcade	Access Invaders	123	**Other**	QuenticC Playroom	48

football club coaching[20], the simulation of interesting brain-teasing management challenges is essential.

Within the strategy genre, the so-called incremental games have gained some popularity in audio gaming. A great and simple example is *Revelation*, developed by Jeremy Kaldobsky (better known as Aprone)[21], in which players start with just 36 objects/elements (such as water and sunlight) and have to combine them in different ways to generate new items. Recently, the Minecraft-like multiplayer game *Survive the Wild (STW)* developed by Sam Tupy[22] is referred as one of the newest audio games that blind players tend to gravitate towards [4]. In *STW*, players have to survive in a post apocalyptic world, building items, fishing, hunting, completing quests, investigating places to find useful items and helping other players in danger — all accessible through audio-only interfaces.

In contrast to exploration and strategy games, action games are typically demanding in terms of dexterity, implying various coordination and reaction challenges within a certain time limit. This is patent in many of today's most popular games such as shooters, RTS (real-time strategy), sports, fighting and racing games. As seen in Table 2.1 there is a substantial collection of action and arcade audio games, as well as some shooters and racing games. Diverse mechanics are explored in these, although some are recurrent such as *sound hunting*, — 3D sound is provided and the player must explore the map

[20]Hattrick. `https://audiogames.net/db.php?action=view&id=Hattrick` (Last visited on September 15th, 2020)

[21]Revelation. `https://audiogames.net/db.php?action=view&id=Revelation` (Last visited on September 15th, 2020)

[22]Survive the Wild. `http://www.samtupy.com/games/stw/` (Last visited on September 15th, 2020)

to search-and-collect certain objects represented with sound according to its position and distance[23 24] — *sound targeting* — player has to aim or move to different tracks, trying to perceive the position of the sound and clicking when it is close enough or avoiding it[25 26 27 28 29] — and *sound sequence* — consecutive sounds are played and player must use the correct buttons, gestures or other input forms to ensure that the the sequence is matched (challenge posed by most rhythm audio games)[24 30]. Compilations such as Audio Game Hub[31] and Sammy Senter[32] explore different mechanics and similar mechanics applied to different narrative contexts. Curious games originate from real-life challenges where seeing is unimportant such as lock-picking[33] and musical performance [19, 49, 50].

Rhythm/music games were repeatedly explored in past research as an effective way to challenge and entertain both visually impaired and sighted players [30, 49, 98]. *EscapeBeat*[24] combines world exploration, *sound hunting* and rhythmic challenges into a vibrant audio-only experience. The goal is to find the way out of the maze room (the exit is highlighted by a continuous distance/position indicating sound) while fighting the enemies on the beat of the background song.

Adaptation of traditional games are also a common place (such as the seven volumes of Azabat[34]), including word games, like *Scrabble*[35], *Hangman*[36] and *Wordfinder*[37]. *Dog Who Hates Toast*[38] is an original audio word game, in which the player has access to a house, its rooms, different locations and objects through rows of keys on the keyboard.

[23]Super Egghunt Plus. `https://audiogames.net/db.php?action=view&id=super%20Egghunt%20Plus` (Last visited on October 23rd, 2020)

[24]EscapeBeat. `https://gamejolt.com/games/EscapeBeat/291088` (Last visited on October 23rd, 2020)

[25]Screaming Strike. `https://audiogames.net/db.php?action=view&id=Screaming%20Strike` (Last visited on October 23rd, 2020)

[26]Duckblaster. `https://audiogames.net/db.php?action=view&id=Duckblaster` (Last visited on October 23rd, 2020)

[27]Blindfold Runner. `https://audiogames.net/db.php?action=view&id=Blindfold%20runner` (Last visited on October 23rd, 2020)

[28]Banjobuster. `https://audiogames.net/db.php?action=view&id=banjobuster` (Last visited on October 23rd, 2020)

[29]Mole no more. `https://audiogames.net/db.php?action=view&id=Mole%20no%20more` (Last visited on October 23rd, 2020)

[30]Sonic Match. `https://audiogames.net/db.php?action=view&id=sonicmatch` (Last visited on October 23rd, 2020)

[31]Audio Game Hub - Keep Your Ears Wide Open. `http://www.audiogamehub.com/` (Last visited on October 23rd, 2020)

[32]Sammy Senter. `https://audiogames.net/db.php?action=view&id=Sammy%20Senter` (Last visited on October 23rd, 2020)

[33]Lockpick. `https://audiogames.net/db.php?action=view&id=lockpick` (Last visited on October 23rd, 2020)

[34]A Z A B A T | Accessible Computer Games. `http://www.azabat.co.uk/games.html` (Last visited on October 23rd, 2020)

[35]BG Scrabble. `http://www.omninet.net.au/~irhumph/bgscrabble.htm` (Last visited on October 23rd, 2020)

[36]BG Hangman `http://www.spoonbillsoftware.com.au/bghangman.htm` (Last visited on October 23rd, 2020)

[37]Wordfinder, `https://audiogames.net/db.php?action=view&id=Wordfinder` (Last visited on October 23rd, 2020)

[38]Dog who hates toast. `https://audiogames.net/db.php?action=view&id=Dog%20who%20hates%20toast` (Last visited on October 23rd, 2020)

The goal is to comply with the housekeeper's orders ("*put the toothbrush that is in the bathroom sink, under the bedroom carpet*") which goes more and more insane. Once a task is completed, the player is informed that a particular word will be replaced by another. The challenge to memory and word association becomes progressively more difficult and fun, resulting in absurd and humorous sayings.

Other research studies evaluate the potential of games as a fun way to exercise — so-called exergames — specifically aimed at blind people [59, 60, 61, 62]. These studies have shown that blind and low vision people seem receptive and engaged when gameplay uses full-body gestures. Still, the development of motion-based games for people with visual impairments becomes more difficult, especially in a social context, as the perception of surrounding space becomes critical and the player has to feel comfortable performing the necessary moves.

Haptic stimulation is also a possibility that should always be on the table when it comes to games for people with visual impairments. Namely vibrotactile feedback is a common feature on commodity gaming devices — console controls and smartphones — and is often used to enrich the experience. Some games imply the use of specialized controllers and props [67, 87, 92] — tangible interaction is often explored in gaming scenarios for blind people [32, 57, 98] — potentially making the gameplay more interesting but also making the game less readily available. Yuan and Folmer [98] explored the adaptation of a popular rhythm game, *Guitar Hero*[39] which, despite being a game about musical performance, depends on visual interaction. Adaptation leveraged the use of a glove with small pager motors attached to the tip of each finger, which transmit the information of the notes that must be played.

The feeling of progress (achievement and advancement) and the arousal of curiosity (allied with significant diversity) are key attributes in many games and essential for replayability [97]. These can be crucial to engage and stimulate players, when input and output must be somehow limited. Restrictions can be leveraged through focused game design — player actions are limited but tuned to create emergent gameplay. This is pointed out in the definition of mechanics and types of mechanics by Sicart [77]. The author gives the example of *Nintendo's Bit Generations*, a collection of games that assume core mechanics as the only mechanics. Another example of this, also from *Nintendo*, is the party game *1-2-Switch*[40], which puts two players face to face, competing in diverse mini-games. It was shown to be an appropriate game that players with and without visual impairments can enjoy together[41]. Notably, in *Crazy Party*[42], while gameplay is usually simplistic, the diversity and feeling of progression keep the game interesting — the player is constantly challenged with new and varied tasks. In adventure mode, the player has to browse different worlds — e.g., the "Valley", the "Castle" — and surpass different challenges to progress on the map. Before the

[39] Guitar Hero. `https://www.guitarhero.com/` (Last visited on October 23rd, 2020)

[40] 1-2-Switch. `https://www.nintendo.pt/Jogos/Nintendo-Switch/1-2-Switch-1173186.html` (Last visited on October 23rd, 2020)

[41] James Rath. *Blind People Play Nintendo Switch*. URL: `https://www.youtube.com/watch?v=lpDoYgGC9QI` (visited on 10/18/2019), Steve Saylor. *BLIND GAMER plays 1-2-Switch with friends! (Nintendo Switch Gameplay)*. URL: `https://www.youtube.com/watch?v=GtolhhuW_Dw` (visited on 10/18/2019).

[42] Crazy Party, audio mini-games and battle! `http://pragmapragma.free.fr/crazy-party/en/` (Last visited on October 23rd, 2020)

challenge starts, a normally absurd and humorous situation is described — e.g., "*the duck is walking in the rain and you have to escort it with an umbrella*" — and the rules along with controls and relevant sounds are presented. Additionally, there are online matches, in which players compete to reach the end of a route — like in a board game — progressing with dice rolls and the completion of these mini-games. Being a game that stands out for its flexibility, it also offers an alternative strategy-based multiplayer gameplay — battle mode, which consists of a deck-building card game.

As demonstrated, initiatives to create accessible and interesting games for people with visual impairments — even though not comparable at all to the mainstream gaming industry — are diverse. Like these, there are a significant number of efforts seeking to develop enjoyable games for those with motor [17, 28, 41], hearing [56] and cognitive [64] disabilities. Previous work surveyed and assorted some of these efforts [99]. However, research and industry tend to focus on a very specific player profile with a specific set of abilities. Thus, we note a lack of research in mixed-ability playing and in reported ways to make it possible and prevailing.

2.2 Mixed-ability group play

As mentioned before, some multiplayer games unfold to be playable by players with different abilities, even when these are not fully or purposefully accessible — e.g., text-based MMORPGs and fighting games are played by players with different levels of vision. We highlight some of the research efforts and indie game industry initiatives that have previously sought for ways to engage people with different abilities in the same (symmetric) gameplay.

Developed by researchers Brederode *et al.*, *powerBall* [17] is a game that takes advantage of augmented-reality to bring together 8-14 year old children with and without learning/motor impairments and encourage social interactions during the experience. Graphics are projected onto a table and physical elements are used to affect the trajectory of a ball (big buttons that accelerate, attract or repulse it). Social gaming is stimulated by the horizontal display, by combining cooperative and competitive dynamics and by encouraging interactions with both virtual and physical elements.

Just like in *Nintendo 1-2 Switch* gameplay, *WaTa Fight* [44] puts two players face to face and declares as the winner the one who is faster and/or more accurate on a given task. It is developed to be played by people with and without visual impairments. Players are fighting ninjas, each one with three honor points (health points) and must press two buttons (Wa and Ta) on each side of the smartphone to attack and block the opponent. Playtesting with mixed-visual-ability groups has shown the game stimulated sociality and the sense of integration. Curiously, at first, the game interface consisted of six buttons, but after user studies, it was concluded that players preferred it more simplistic.

Jeremy Kaldobsky is an active audio game developer[43]. His work has granted a diverse collection of interesting audio games and accessible software and reflects a motivation to create games that both sighted and visually impaired players can enjoy. In *Castaways*[44]

[43]Aprone's Accessible Software and Games. `https://www.kaldobsky.com/ssl/audiogames.php` (Last visited on September 16th, 2020)

[44]Castaways. `https://audiogames.net/db.php?action=view&id=Castaways` (Last visited on October 23rd, 2020)

and *Castaways 2*[45], players take control of the few survivors of a shipwreck on a savage, goblin infested shaw. The goal is to gather resources, train up soldiers, place workers and build new things. Multiplayer allows for trading, buying, and selling resources to other players. Also very popular, Aprone's *Swamp*[46] is a shooter played from above in a zombie-infested town that happens to be located near a swamp. Players control turning and aiming of weapons with the mouse. The game is referred by blind gamers as one of recent games played with sighted friends and family [4]. Both these games display minimalist graphics that can make the game more engaging for sighted players, but do not give them any advantage.

Figure 2.5: In Aprone's *Castaways 2*, players have control of grid-structured regions and must carefully manage their resources and place their workers.

There is research into Universally Accessible (UA) Gaming. Namely, there is the adaptation of traditional games like chess [34] and tic-tac-toe [66] as well as complex games that include free world navigation [86]. This work is incredibly informative for game accessibility and proves to be above all very important for the establishment of accessibility guidelines. Social Game Hubs i.e. multiplayer rooms in which players join and play together games are also designed to accommodate players with different abilities. Notably *QuentinC's Playroom*[47] has a diverse collection with digital versions of traditional and card games. All games are based on text commands, but some offer supplementary graphics. In Portugal, there are conversation rooms accessed by dialling a phone number, in which people can play typically turn-based games (e.g., word, trivia games) with other people on the call by taking actions through speech and number keys.

There are options for mixed-ability group play. However, as already pointed, the symmetry of gameplay usually ends up limiting the experience to someone, depending on the abilities and preferences of each player.

[45]Castaways 2. `https://forum.audiogames.net/viewtopic.php?id=18518` (Last visited on October 23rd, 2020)

[46]Swamp. `https://audiogames.net/db.php?action=view&id=Swamp` (Last visited on October 23rd, 2020)

[47]QuentinC's Playroom. `https://audiogames.net/db.php?action=view&id=Quentin%20C%20playroom` (Last visited on October 23rd, 2020)

2.3 Asymmetric roles in gaming

Asymmetry can arise at various levels in gameplay (e.g., players have different character abilities). In some games a complete asymmetry is included within the design (i.e. players have very different ways of interacting and share little or no mechanics) [25]. Harris and Hancock [38] found, through a collaborative two player experience study that social presence and connectedness are higher in asymmetric play than in symmetric play, and even higher when tightly-coupled collaboration (i.e. higher interdependence) is involved. Participants claimed that the experience is perceived as more immersive and the controls feel more intuitive when the roles performed are asymmetric. Additionally, asymmetry reveals possibilities of combining analog with digital gameplay as it happens in *Keep Talking and Nobody Explodes* (KTNE)[48]. KTNE was designed to be played by at least two people — one is the "Defuser", playing through the computer, smartphone or VR device and the remaining players are the "Experts" that read the bomb disarming manual and try to give useful information and instructions to the Defuser. This is a good example of complementary information mechanics, since the Defuser cannot read the manual and the Experts cannot see the bomb. Interaction is not complex, but communication becomes crucial and takes place locally or via online. Accessibility options are provided for colorblind players, but the game is unplayable without vision.

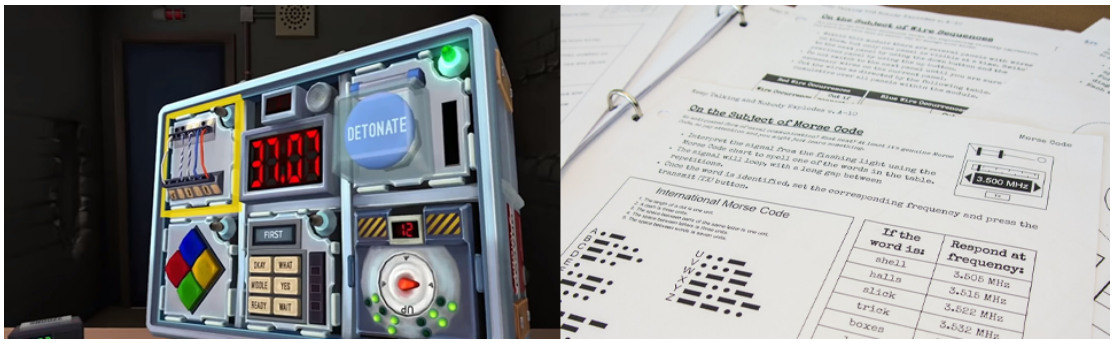

Figure 2.6: In KTNE, the Defuser has access to the bomb and the Experts have access to the bomb disarming manual. Players have to reach effective communication to successfully disarm the device.

In digital gaming, we can find the use of asymmetry and collaboration in diverse cases. *Cook, Serve, Delicious!*[49] has a co-op mode where one player is cooking and the other player is managing orders. *VR The Diner Duo*[50] has a similar multiplayer dynamic, in which a person plays as the chef in VR display and another person embodies the waiter, playing on a computer. *Clandestine*[51] is yet another example of asymmetry, consisting of two interdependent roles — the spy, which involves a typical third person

[48]Keep Talking and Nobody Explodes - Defuse a bomb with your friends. https://keeptalkinggame.com/ (Last visited on October 23rd, 2020)

[49]Cook, Serve, Delicious! https://store.steampowered.com/app/247020/Cook_Serve_Delicious/ (Last visited on October 23rd, 2020)

[50]VR The Diner Duo. https://store.steampowered.com/app/530120/VR_The_Diner_Duo/ (Last visited on October 23rd, 2020)

[51]Clandestine. https://store.steampowered.com/app/290530/Clandestine/ (Last visited on October 23rd, 2020)

stealth gameplay and the hacker, responsible for cracking infrastructure and defeating security systems through a birds-eye view of the map and a grid display. It is heavily reliant on patience, communication and teamwork, since the contribution of the two players is imperative for the secret infiltration success.

Asymmetric roles are also widely explored in tabletop gaming. Based on traditional *Battleship*, *Captain Sonar*[52] is a board game in which players organize themselves into teams sitting on opposite sides of the table and take a particular role on a submarine. Each team is trying to locate the opposing submarine in order to shoot it before the same happens to its own. All four roles and communication between players are crucial. The captain is responsible for submarine movement; sonar operator must listen to the opposing team, trying to decipher where their sub is; the first mate might prepare torpedoes, mines and other devices that allow for combat; finally, the engineer, who ensures the submarine is properly working. Sonar manning entails a *listen-and-deduct* kind of challenge that, in a different context could be an interesting vision-independent role. However, all roles are inaccessible (actions are drawn in plasticized papers with maps and submarine representations). Despite its strategic nature, the game proves to be very dynamic and intense. Alternatively to standard turn-based mode, Captain Sonar has a real-time mode for experienced players looking for faster paced gameplay. This is an example of a game that excels in flexibility — players can choose the role that best suits their personal taste and skills, and they can also choose the game mode given their preference for pace and group experience. Unfortunately, like most board games, it is reliant on visual interaction.

Figure 2.7: In Captain Sonar, each team of players sit on one side of the table, trying to perceive the position of the opponent and moving away from torpedoes and mines.

Determined to create a board game that could be played by her blind uncle with no modifications required, Catherine Stippell created *Nyctophobia*[53], a game in which sighted players are the ones that have to adapt. All but one of the players play the game

[52]Captain Sonar. `https://boardgamegeek.com/boardgame/171131/captain-sonar` (Last visited on October 23rd, 2020)

[53]Nyctophobia. `https://boardgamegeek.com/boardgame/249505/nyctophobia` (Last visited on October 23rd, 2020)

unable to see the board. The blind (or blindfolded) players must navigate the map, trying to escape the Hunter, who is tasked with killing at least one player before the police arrives. Navigation is ensured through tactile interaction. In When I Dream[54], one of the players is the Dreamer and has to guess different words, while the other players give clues. The Dreamer must wear a blindfold so he cannot read the cards that every remaining player can.

Figure 2.8: Nyctophobia is a one-versus-many survival horror game where blind/blindfolded players can only interact with the board through touch and have to navigate a dark forest without falling victim to the sighted player who is hunting them down.

Asymmetric roles were lightly explored in gaming for mixed-ability contexts before. Grabski *et al.* developed *Kinaptic* [32], a tag-like game to be played by one blind and one sighted person. The sighted player has access to visual feedback through a television and can interact through the Kinect camera. The blind player experiences the environment using a haptic device, wind simulation and 3D sound. The multimodality is the main focus on the study — user studies seek to understand whether the different input and output possibilities applied are sufficient and appropriate to transmit the same resolution of information compared to that transmitted through the visual channel. The user study shows that both sighted and visually impaired players had a fair winning chance. However, the use of asymmetric roles is not further explored or evaluated.

We highlight the motion-based two-player game *Last Tank Rolling* [28], in which one wheelchair-user and one body-abled player collaborate through an asymmetric gameplay, in a war scenario, avoiding the obstacles and destroying enemies to reach the goal. The movement of the wheelchair is metaphorically and physically linked with the control of a virtual war tank, which is tougher and more powerful, but slower than the foot soldier controlled by the second player. Each role is designed according to the abilities of each player, turning what is normally seen as a limitation (the use of a wheelchair) as an empowering element and an essential contribution. Moreover, the emergent interdependence of such setting is a catalyst for social play.

Grammenos *et al.* present, through the development of *Access Invaders* and its descendant *Terrestrial Invaders* [35, 36] the concept of Parallel Game Universes. Customized profiles are used to adapt the interface and difficulty to the player. This way, players can play in different *game universes*, which can be bonded, in this case within a

[54]When I Dream. `https://boardgamegeek.com/boardgame/198454/when-i-dream` (Last visited on October 23rd, 2020)

cooperative experience. However, by proposing the same role and task to both, the solution proposed is to reduce the difficulty of the game for players who cannot keep up with the challenge. We point out the negative effect of this specific approach — the portrayal of players with disabilities as less capable and their contribution as less valuable. An accessible gameplay, even when it implies a more simplistic interaction does not have to necessarily equate to an easier game. It is important to distinguish complexity at the different levels of design and gameplay. As, such, formal approaches are needed to accentuate this distinction and refine the implementation.

2.4 Frameworks for games

Research have suggested a number of different structural models, looking for efficient ways to understand, communicate and develop games. Hunicke *et al.* [43] decomposed gameplay into a three-tiered model and described its perception from two different perspectives — as in designing the game and as in playing the game. These three layers, also compared to "*concept lenses*" are Mechanics (operations and actions afforded, e.g., shuffling and betting in Poker), Dynamics (emerged behaviours and strategies from mechanics, e.g., bluffing) and Aesthetics (perceived aspects by the player, e.g., the excitement of having a good Poker hand). Understanding this formula allows designers to analyze the motivating elements of the end result and to predict the outcome of implementation changes. More importantly it facilitates the communication among designers. This concept gains great prominence in our approach, since the gameplay dynamics — arising from an interdependent collaboration of people with different abilities in a playing environment — as well as the perceptions, sensations, and behaviors resulting from this interaction, both depend on the implementation of mechanics and their mapping to abilities.

Typically, mechanics are defined and communicated as verbs, as actions that the player takes — in Poker, the player can *check*, *bet* and *fold* — and programmed reactions marked as events — in digital games, the system automatically *shuffles* the cards (it is not a result of agency but it is also a mechanic). The mapping between game mechanics, input modalities and player experience has been theorized before[77]. Mechanics are triggered by input processes which ensures interaction, altering the state of the game according to the established rules — hence, input generates mechanics and different states, depending on the decision and performance of the player. In this context, it is also important to highlight Sicart's definition of compound mechanics — "*a set of related game mechanics that function together within one delimited agent interaction mode*". *Driving*, for example is composed by more fine-grained mechanics such as *accelerating*, *braking* and *steering*. Therefore, we must note that *driving* is also contiguous with multiple input processes (i.e. multiple buttons are pressed).

The combination of different mechanics and their application in different contexts generate countless possibilities. For example, although *jumping* is a core mechanic in both arcade *Donkey Kong* [63] and parkour 3D simulator *Mirror's Edge* [24], implementation is significantly different, as are the dynamics that emerge from each. Björk *et al.* introduce the concept of game patterns as recurring features and behaviors resulting from gameplay [10]. From insistent analysis they identify more than 200 patterns, defining them by a name, a description, relation with other patterns, use and its

consequences [11]. This research work becomes very useful for ideation, concept development, communication between designers, game analysis and categorization. Similarly, Accessible Player Experiences (APX)[55], provided by AbleGamers, proposes a set of design patterns intended to support ideation and provide inspiration for accessible design. These are divided into patterns that allow access to content and patterns that enhance the enjoyment of the gameplay, and describe the problem, possible solutions and examples from the industry. This practice is based on the reasoning that, instead of questioning how to make the game accessible, we should look at how to make the *experience* accessible and, in an indispensable second step, engaging for everyone.

Still, two players can be so different, just in light of their preferences and experience, that alone may already be reason why they could not enjoy the same gameplay. For example, prior research establishes that older adults tend to play more casual games than younger gamers [48]. Some design options are commonly used to address this issue — e.g., choosing the difficulty at the start of the game and customization options. Player-adaptive games are also investigated and theorized by frameworks [20, 21]. Adaptation can be ensured by predetermined options and by using player information and performance to learn and provide custom experiences. In symmetric multiplayer games, this adaptation may be substantial. When gameplay is asymmetric, adaptive options may optimize interaction and engagement, however asymmetry itself offers flexibility to fit different preferences, experience and, most importantly in this context, the abilities of each player.

[55] AbleGamers Accessible Player Experience. `https://accessible.games/accessible-player-experiences/` (Last visited on May 7th, 2020)

Chapter 3

Delving Into Mixed-Ability Gaming

It is necessary to find ways to include different needs and preferences in the design. As such, it is important to understand the impact that different abilities have on people's experiences, preferences and perceptions regarding gaming. Gerling *et al.* [29] explored the creation of a wheelchair-controlled digital game following a participatory design approach, first with a group of wheelchair-users and then with game design experts. The study shows significant differences in the game concepts suggested by each group.

Porter and Kientz [68] asked people with disabilities to express their habits, preferences, and concerns regarding gaming. Participants seemed to engage in single-player gaming significantly more often than in multiplayer, especially those with visual impairments. The authors highlight this was not expected, given the rising popularity of multiplayer games on the various platforms. Most barriers identified by participants were merely technical, such as the incompatibility with assistive technology (e.g., screen readers). However, some participants with motor impairments expressed their concerns regarding multiplayer experiences, namely the discomfort of failing when competing against able-bodied gamers.

Urbanek and Güldenpfennig [90] approached experienced audio game players and designers, issuing a rich characterization of the audio game genre and experience. Their work offers valuable insights that do not focus on accessibility barriers but on perspectives regarding game design, personal experiences and community. Similarly, Andrade *et al.* [4] published a study focusing on the experiences of a group of blind players. The authors particularly highlight what the group values in games, such as the feeling of agency over the narrative, but also negative aspects, for instance, a perceived lack of complexity in games. Gamers with visual impairments have also reflected on common interaction patterns of audio and text-based digital games [3].

These studies revealed opportunities and concerns shared by people with disabilities, which is imperatively important to inform future work on accessible and inclusive gaming. In these, people with visual impairments seemed to prefer to play alone [4, 68]. However, reasons behind this were unclear. We found a lack of understanding in regard to multiplayer accessible gaming and particularly mixed-ability gaming.

As a start goal of this thesis, we conducted a characterization study, aiming to learn more about the background, current opinion and future perspectives of people with visual impairments on playing, playing with others, and playing collaboratively, and also on the different accessible games and genres. We focused this characterization on multiplayer

experiences, particularly on mixed-ability experiences i.e. playing with sighted friends and family. In short, we wanted to probe:

1. What characterizes the experiences of people with visual impairments when playing games with other people?
2. What barriers stand in the way of people with visual impairments when playing and playing with others?
3. What opportunities emerge in designing for mixed-ability gaming?

3.1 Procedure

We conducted semi-structured interviews with visually impaired people, namely individual interviews with adults and group interviews with minors and educators. Informed by the first interviews, we launched two online questionnaires, one to be answered by people with visual impairments and the other to be answered by sighted people who play with someone with visual impairments. We then proceeded to data analysis. The study was approved by the Ethics Committee of FCUL. The documents required to conduct the study are available: the informative briefing for interviews (appendix A) and questionnaires (appendix B); informed consent for adult interviewees (appendix C) and minor interviewees (appendix D).

3.1.1 Interviews

Interviews focused on group play, covering subjects such as playful experiences with family and friends, competition and collaboration in games and non-digital playing — i.e. board, card and talking games. We adapted interview questions to each group. For example, in the group interviews with younger participants and educators, we asked questions regarding gameful activities at school. The script used to guide interviews is available in appendix E. On average, individual interviews lasted 30 minutes and group interviews 50 minutes. Some adult participants were kind enough to demonstrate some of the accessible digital games they play on their computer or smartphone. Likewise, educators also presented various accessible analog games used in schools.

3.1.2 Online Questionnaires

We built two online questionnaires. One (Q-VI) was to be answered by people with visual impairments, focused on their playing habits, with a particular interest on the barriers that arise when playing alone and with others. The other (Q-S) was to be answered by sighted people that have close contact with at least one individual with visual impairments, focusing on group play experiences with that person. The full structure of both questionnaires are provided in appendices F and G.

We advertised questionnaires through mailing lists, social networks and forums, related to communities of people with visual impairments, support networks and audio gaming. We invited people aged 18 or older to participate. To proceed with the questionnaire, all participants verified that they were of this minimum age, also consenting to take part in the study. We collected responses during five months.

The analysis of open ended questions from the questionnaires allowed us to expand and consolidate the findings of the interviews we were performing locally. We collected valuable responses from participants who were more experienced gamers and framed their perspectives regarding mixed-visual-ability gaming experiences.

3.1.3 Participants

We contacted local training institutions for people with visual impairments, where we conducted the first interviews. The group was mainly composed of older visually impaired adults. We decided it would be important to get the perspective of younger people (between 11-18), as age is a factor that influences gaming preferences, motivations and experiences [9]. We proceeded to recruit young participants from public schools with a leading role in the education of blind and low vision minors in our country. In these, for reasons of logistics and minor protection, group interviews were conducted, in which special needs educators also participated. Given their role in schools, and how embedded they became in their students' lives, educators gave an additional lens of the gaming habits, barriers and perceptions of their students, besides the barriers they have faced when procuring accessible gameful material.

We interviewed 10 blind adults (I1-I10), 5M and 5F, aged 34-60 (M=47.6, SD=8.1); a group of 7 minors, five blind and two with low vision (I11-I17), 5M and 2F, aged 11-18 (M=13.1, SD=2.8), and two special needs educators, one who was blind; and a group of 3 minors with low vision (I18-I20), 2M and 1F, two aged 13 and one aged 17, joined by two special needs educators. Individual interviews were on average 30 minutes and group interviews took approximately 40 minutes each.

To the first questionnaire (Q-VI), we collected 140 valid responses (R1–R140), 77M and 55F (3 preferred not to say), aged 18-64 (M=35.1, SD=13.7), from 22 different countries. 67 of the respondents were totally blind (no light perception), 52 of them had severe low vision (visual acuity lower than 6/60), 16 had mild to moderate low vision (visual acuity between 6/12 and 6/60), and 5 preferred not to say.

To the second questionnaire (Q-S), we received 17 valid responses (S1-S17), 2M and 14F (1 preferred not to say), aged 28-61 (M=43.7, SD=8.6). We asked participants to consider the visually impaired person with whom they have more frequent contact (whom we named Charlie throughout the questionnaire) and to respond regarding multiplayer experiences with that person. We quantified the frequency with which sighted respondents play with visually impaired partners: regarding digital games, 4 respondents play daily with Charlie, 1 plays weekly, 1 plays monthly, 4 play occasionally and 7 never play; regarding tabletop games, 1 plays daily, 2 play monthly, 8 play occasionally and 2 never play. Charlies were 10M and 6F (1 respondent preferred not to say), aged 6-73 (M=27, SD=17.9) and were identified as a child (8), friend (4), partner (2) and student (3).

Some respondents to the first questionnaire (Q-VI) chose to send e-mails in which they detail their experiences and perspectives regarding gaming. These contacts were mostly due to the sharing of online questionnaires on mailing lists. These responses were also analyzed and contributed to the reinforcement of our findings.

3.1.4 Data Collection and Analysis

Interviews were audio recorded and transcribed. These transcriptions, open questions to the questionnaires and extra emails received from participants constituted our data. We used inductive thematic analysis (TA) with an experiential orientation under an essentialist theoretical framework [15]. Following the six phases of TA [16], first we familiarized ourselves with the data by reading and re-reading followed by inductively generating an initial set of codes. We continued this phase by refining codes through multiple coding iterations and discussions among us. Aiming to promote discussion and to ensure a shared view, we verified inter-rater reliability — two researchers (David Gonçalves and André Rodrigues) independently coded 2 individual interviews, 1 group interview and 10% of survey responses, leading to a Cohen's kappa agreement of k=0.79. For the next three phases (searching, reviewing and naming themes) we started by close reading codes' excerpts and exploring codes' relationships. The themes were progressively created, iterated, merged and discarded through several iterations of theme summaries with supporting statements and descriptions. We provide the final codebook (with descriptions and examples) and aggregated themes in appendices H and I, respectively. Below we thoroughly present the themes that led our discussions.

3.1.5 Study Limitations

This study provides an in-depth analysis of the perceptions and perspectives of people with visual impairments playing games with others. We attempted to recruit sighted people who had experiences playing with visually impaired people, but we were unable to recruit a large number of participants. Therefore, our findings and ensuing discussion reflect the views of participants with visual impairments and are supported by the insights of sighted participants, namely in relation with sighted play.

3.2 Findings

This work allowed us to understand the participants' personal preferences and perceptions on playing and playing with others, and this alone allowed us to enrich our vision and better guide the project into the next phase. We introduce a brief characterization of visually impaired participants' playing habits. We then present our findings centered on the themes that reflect our analysis. We present subjects that may not be exclusively related to multiplayer experiences, but we are careful to frame them in the social context of gaming.

3.2.1 Gaming habits

Quantitative data collected from the first questionnaire (Q-VI) is presented in full in appendix J. Data indicates multiplayer experiences of respondents are infrequent (Figure 3.1: A and C). 19% of the respondents never play digital games with other people (27) (Figure 3.1: A). This is congruent with previous studies [4, 68]. Digital multiplayer gaming is overall less frequent for participants with severe low vision. Respondents mainly play digital games with *real-life* friends (65) and online friends (62) (Figure 3.1:

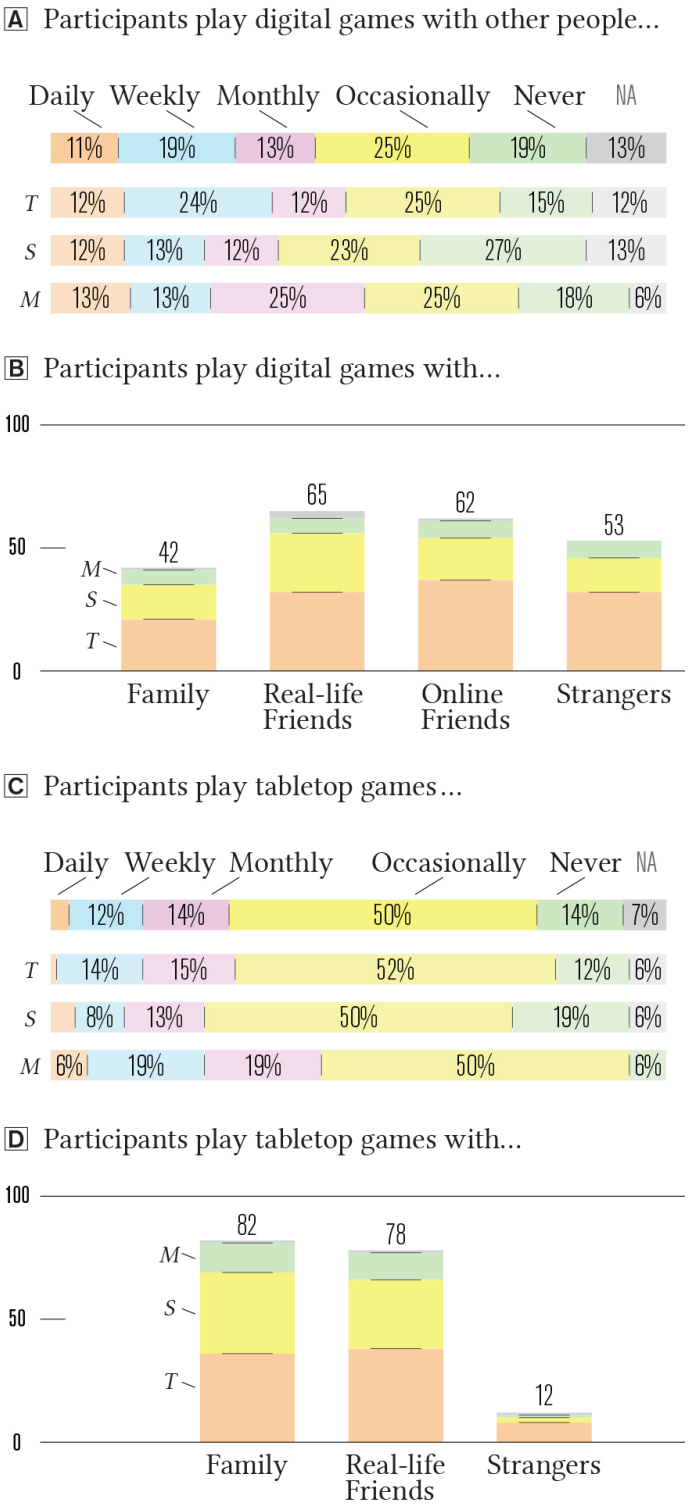

Figure 3.1: Gaming habits of respondents to the first survey (Q-VI) particularized by visual impairment of respondents: total blindness (T), severe low vision (S) or mild to moderate low vision (M). A — Frequency with which participants play digital games with other people; B — People with whom participants play digital games; C — Frequency with which participants play tabletop games with other people; D — People with whom participants play tabletop games.

B). On the other hand, they mainly play tabletop games with family (82) and *real-life* friends (78) (Figure 3.1: D). Participants reported experiences with tabletop games as much less frequent than digital gaming. Despite this, fewer respondents marked that they have never played tabletop games with other people compared to digital gaming.

Due to a growing diversity of accessible games and assistive software, blind and low vision people are playing varied digital games. Most interviewees currently search autonomously for accessible digital games on the Internet. However, some reported that they are unsuccessful in finding games or that those they found seem unsafe and they did not felt confident in installing them on their devices.

Most interviewees stated they mostly play alone, either single-player or against AI. When playing with others, they mainly play with other visually impaired people. In the first group interview with younger participants, we found that it was unusual for them to play with others with different visual abilities, with the exception of their sighted teacher. Multiplayer games mentioned in interviews and surveys were almost always competitive. Some participants reported that they like the unpredictability and challenge that grows when they are playing against someone else. Games that were mentioned with a collaborative aspect were competitive games between teams such as card game Sueca. However, generally, all interviewees shown interest in collaborative dynamics. Their general perception is that collaboration between players encourages greater interaction.

We noted that mixed-visual-ability playful experiences were almost always related with mainstream tabletop games (e.g., *Uno*, *Trivial Pursuit*). When playing tabletop games, some participants use assistive software to read printed information, maintain game sheets and roll dice. Moreover, participants often play digital versions of tabletop games, reasoning that pieces, dice and cards are not readable in most physical versions.

Many of the digital games played by participants involve complex worlds and challenges, namely Role-Playing Games (RPG) and simulation games, or imply dexterity, such as shooters and racing games. Among participants, some manage to play highly visual mainstream games. These highlighted the struggle when using emulators or assistive software to play certain games and the effort required in some tasks, in which their impairment makes it more difficult to succeed:

> "*I manage okay with most games aside from games with Quick Time Events (QTE) which mean I have to repeat the over and over as I miss the prompts. The worst for me was God of War 3 where the QTE prompts appeared at random on the edges of the screen. This game drove me to tears as I could not see them.*" – R16

> "*Many blind people, who have heard about the new accessibility mode in Retroarch, have spent days just trying to configure the software to work, showing me that blind people really want to play great games.*" – R22

Other participants pointed out they usually only play games they know in advance are accessible. Some stated they appreciate the variety of accessible games available. However, none of the participants were satisfied with the possibilities to play with others given the lack of enjoyable games to play with people with different visual abilities.

3.2.2 Excluded from play

For participants with visual impairments, the fact that the vast majority of games are vision-dependent restricts possibilities of playing with sighted family and friends, and inhibits their interest in gaming. Some described experiences where they were excluded from the game or group because other people wanted to play inaccessible games:

> "*It has happened to me a lot of annoying situations where there is a big group and I had to put myself aside and say I didn't feel like playing. [...] I had to leave because it was not accessible to me. It's annoying because we are a group [...] and in the group everyone sees but me.*" – I3

> "*Sometimes my family plays Monopoly [standard version]. And when they play Monopoly I just can't play with them. They happen to be careful when they choose games that we are all supposed to play. They usually choose games in which I can be integrated. But sometimes they just play Monopoly.*" – I4

They reported to have tried to engage sighted family and friends with accessible games, but games that are specifically adapted for blind people are ignored by most sighted people:

> "*Not everyone has Playroom, because Playroom has been adapted for blind people. There's the part of selfishness that is unconscious. Who doesn't need it, doesn't feel it. [...] We continue to be in a world apart. And it's better than nothing but it's not the same thing.*" – I3

Some participants stated that one of the biggest barriers to an interest in gaming is not knowing what exists and not having someone to guide you through it: "*There are a lot of visually impaired people who end up not even having a clue what it is, because they don't know anyone who would tell them about it*" (I4). One of the teachers in the first group interview explained that some blind children are not interested in games because they are unaware of what exists and assume there are no engaging games for them.

On the other hand, participants with visual impairments described situations in which they avoid getting involved in games that family and friends are playing to avoid the frustration of not being able to play. In the second group interview, one participant reported that he does not even try to play games that sighted friends play, as he assumes they are "*normal games*", in this case games not claimed as accessible or specifically designed for blind people. One of the survey respondents highlight that sighted people often assume that he cannot or would not want to play certain games and that alone can be an impediment to group play.

From the participants' perceptions, despite the lack of accessible games, what stands out is a lack of intersection of playing habits between people with different visual abilities. One respondent to the first questionnaire (Q-VI) highlights that sighted people often assume that he cannot or would not want to play certain games, thus jeopardizing group play. Some participants frame this exclusion in a broader social dimension, highlighting the disconnectedness that exists between people with different visual abilities:

> "*Games are a very crucial part of social society. If they were all, or most of them were made accessible, then the blind community would be very appreciative. Games provide a barrier that traps us in a bubble that does not allow us to interact on the same level as our sighted peers.*" – R79

3.2.3 The accessibility burden

We realized that, in several situations, the onus of accessibility is pushed upon the gamer with disabilities. Many of the participants with visual impairments adapt analog games that are inaccessible, for example, by adding braille or using materials to give different textures to components:

> "*When companies produce and manufacture games, they could immediately give a different texture to white and black pieces, for example, in checkers and chess. Because I have to buy a specific chess board for people with visual impairments or else, for example in the case of checkers it has happened many times that I mark pieces myself.*" – I4

Since most sighted people do not own accessible games, participants with visual impairments have no option but to make sure they have their adapted versions in group play situations: "*I always have to take my own [cards]. [...] I think that all the cards, all that are sold out there should be marked [with braille]*" (I3). In past experiences of some participants, the group agrees to slightly change some rules of the game so that everyone can be included:

> "*We modify some games to make them more blind accessible, like making sleeves for cards. For some games, we change the rules slightly by making some private information public. Sometimes we play with teams playing one position so that each team has a sighted player.*" – R108

However, in many of the cases described, participants with visual impairments end up trying to play games that are not accessible: "*Those who are sighted don't want to play games that are blind accessible so I have to play games that aren't, limiting my ability to actually be a full player*" (R109).

3.2.4 Feedback, fairness and hedonism

As mentioned, participants with visual impairments repeatedly stated that most sighted people do not care about the games they play. This was corroborated by perspectives of sighted participants: "*Not all games are accessible to those who are visually impaired and those that are often are uninteresting to those who are not.*" (S3). The reason often provided was games specifically designed for people with visual impairments do not have graphics or, when they do, they are not appealing enough. "*I've noticed that, when I talk about Playroom to sighted people, they're not very attracted. Because it really has an audio component, but it has virtually no image at all*" (I8). Moreover, one interviewee expressed her dissatisfaction with a racing audio game which visually is just a black screen, stating she wished other people could perceive the game with their vision:

> "*Even if we don't see, I think it must be visible. And not being, I don't like it because others are seeing [me playing] and think I'm crazy. [...] People who are sighted, they will not be attracted to it. Like a television... I have a television, I don't see the image but the image has to be there, right?*" – I3

Many interviewees came to the conclusion that games could be more inclusive if they provide complementary graphics to an audio-based interaction. On the other hand, participants felt that games designed to be visual first could be unfair:

> "*With my daughter, I always lose [in chess]. She has a better awareness of the board — more global, right? She could immediately define how to develop the moves*" – I8

> "*I want to play a game where we have equal advantage — maybe one where we're all blindfolded. For instance, when I play chess, my opponent always has a strategy or they are able to plan out their moves ahead of time. [...] If you can see/memorize what's been played, you know what's left and how to play. I'm a good player, but I know I'm missing things. I just want a game we can be on the same level.*" – R25

This is also pointed out in games where most of the gameplay is accessible, but elements like mini-maps and health-bars are not. Some participants with visual impairments mentioned they are unable to keep up in games involving cooperation: "*Some people don't like to use sound marks to alert me for danger or where to go. [...] The word indicators are small and makes me feel useless*" (R43).

In some cases, unfairness does not detract from the experience. Some participants mention they play some games just for fun with family and friends, even in clear disadvantage:

> "*When I tried to play table football a few times with my cousins, my nephews and even my daughter — it was just spinning and ... [laughs] When it hit, it went, when it didn't, well... I'm a person, I don't care... I love to play for playing.*" – I8

Some participants with visual impairments said they end up putting random cards down, just to be included in some tabletop games. However, most participants value an even playing ground to be able to enjoy the game. Sometimes, this is even a factor that hinders multiplayer experiences:

> "*I don't play much with others because I don't feel it is fair. Most online games are heavily vision-dependent. I used to feel frustrated when playing FIFA with others because I kept missing the ball.*" – R18

Participants with visual impairments mention the extra cognitive effort of memorizing what happens during the game, constantly being told what is happening or what to do, or just play less adequately compared to everyone else: "*If you can see/memorize what's been played, you know what's left and how to play. I'm a good player, but I know I'm missing things. I just want a game we can be on the same level*" (R25).

Curiously, the opposite was also mentioned, a game with no visual interaction is unfair and even "*not accessible*" to sighted people. Some sighted participants mentioned they are unable to participate or help when Charlie is playing, "*as there is nothing on the screen*". Also, it was stressed that many accessible games have simplistic mechanics, do not stimulate sighted people and even the most complex games are usually based on text-based interaction, which is considered not intuitive and "*just boring*" by those who have no visual impairments.

3.2.5 Adaptation trade-offs

In the second group interview, one of the young participants, who has low vision, shared his thoughts about one of the most popular games today, Fortnite. He says that even using magnification tools, the gameplay is impractical, as there are too many things happening on the screen and timing is essential. When asked if there would be adaptations that could be made in order to make it more accessible to everyone he stated "*maybe it would lose the essence of the game, if that kind of adaptation... it wouldn't be Fortnite anymore, it would be another game*". (I18)

During individual interviews, we observed participants who became blind as adults enthusiastically spoke of games played before vision loss. Some stated they would like to play accessible versions of these, such as soccer and arcade games. However, participants also expressed the assumption that these could not be adaptable or that vision would be essential for certain games to be enjoyable. I4, for example, says she would love to play *The Sims*, but even if it was accessible, there would be no interest, being that she would not see the actual buildings.

One of the respondents (Q-VI) who contacted us later for further commentaries stated that it is necessary to accept that audio-based gameplay is simply much more limited:

> "*As soon as the game involves a 2D or 3D map, or tightly timed action, we are completely lost with mainstream games, and I don't see how we can make a game with those elements both enjoyable for sighted people and playable for blind people. The fact is that we are limited with audio compared to what we can represent with graphics.*" – E-mail

He mentions that gamers with visual impairments will most likely remain limited to specific game genres, namely "*audio games, text games, management games, choice-based or turn-based*". Again, participants highlighted the lack of intersection of games played by people with different visual abilities: "*This is one of the biggest shortcomings. Either the game is fully audio, or the game is visual and often not accessible at all*" (I9). One respondent (Q-VI) pointed out that he would like developers to add alternative ways to complete game challenges:

> "*It would also be great for developers to include some form of auto navigation so players don't have to see to get around, so the game could automatically walk the character around to the place you want to go.*" – R129

Several times, regarding both digital and analog games, synchronous time-restricted gameplay was depicted has an obstacle to multiplayer experiences. In many cases, people

with visual impairments require more time to access the same information due to assistive technologies or the inability to process quick visual aids. Participants report how this hinders their multiplayer experiences: "*I used to find when I did this that people didn't want to wait for me to read something, they felt it was too slow*" (R55). This is a factor that can significantly limit the adaptation of multiplayer games to an accessible format.

3.2.6 Assistance and playing together

Regarding analog games, participants mentioned the assistance provided by sighted players, in reading cards, distinguishing components or moving pieces, and how at times it can be troublesome due to the dynamics of the game:

> "*Certain games require secrecy, thus meaning I have to work hard to keep cards, sheets, tokens, a secret, despite occasionally requiring assistance in reading/evaluating them.*" – R29

Participants with visual impairments often rely on someone to play these games, "*which takes time and seems to take away something from the game play*" (R124). In cases where there is the willingness and patience to help, sometimes there is no knowledge or sensibility to assist:

> "*I love games and believe playing games provides important teaching and bonding opportunities with my children. We have many games in our home, but rely on the children to read directions and often move pieces which is a lot of pressure for them.*" – R94

In digital games, providing assistance may also be complicated: "*I'm not very good at describing visual scenes when he needs them. Sometimes we play mystery games and the visual hints can be very subtle*" (S1). These scenarios were associated with the trust that has to exist among players: "*It's a trust exercise to play with others, given that the information onscreen could easily be misreported by others to their advantage*" (R29). Some of the respondents (Q-VI) described past experiences in which they play highly visual games "by proxy" — just listening to the game audio and someone sighted is holding the controller. They point out it can be fun and rewarding for both. In some cases, participants play together with sighted people and have the opportunity to influence the direction or some aspect of the game:

> "*I said that I play a lot of the games listed [answer to a previous question] with other people, but it is mostly them playing with me in the background giving some advice or saying what I want to do or how I want my character to look.*" – R109

One respondent that later contacted us by e-mail shared his experience with a radio show he followed in the past. In this show, the host would run playthroughs of popular video games, mainly story-driven games with choices. Audience was listening to the game being played and, in parts where there were decisions to be made, they could interact with the host through audio calls and social networks, and vote. The respondent says it was an engaging experience, even though it was someone else actually controlling the game, he had agency in an experience that would otherwise be barred to him.

3.2.7 Asymmetric experiences

There were those who shared playing experiences or other activities where the interaction or the proposed challenge is not the same for all players:

> "*I'll be listening to the sound. I won't be seeing. But the person who is with me is seeing. And he might not even be hearing the sounds I'm hearing. [...] There had to be two exits, two channels. [...] I may be listening with audio description, but someone else may be watching the movie and not the audio description. [...] We won't blind anyone, right? The [sighted] person will want to use eyesight to play.*" – I10

Asymmetry was evidenced mainly at the feedback level, when participants suggested ways to make games captivating for both sighted people and people with visual impairments. One of the respondents (Q-VI) who later contacted us by e-mail referred to past experiences with games in which audio gave information that visuals did not, aiming to create cooperation between people with and without visual impairments. Similarly, another respondent referred to the aforementioned board game Nyctophobia[1], in which all but one of the players cannot see the board.

From the perspectives of some interviewees arose the hypothesis that games could be pleasurable for different players, if the game was designed to be challenging in different ways, for different players: "*I think a game is enjoyable and challenging when it fits the kind of activity a person wants to have. The type of interaction the person wants to have with the game*" (I9). When one interviewee was addressing the difficulty of playing real-time digital games with sighted people, he ended up suggesting that there could be different interactions for each player:

> "*It's a little difficult, imagining such a scenario. There has to be... there has to be one game interaction for blind people and one for sighted people. There has to be a very big adaptation there.*" – I1

3.3 Discussion

Within the concerns, perspectives, and desires of the participants lay design limitations but also opportunities for future work in mixed-ability gaming. Whereas this study, as all the research in the thesis focuses on mixed-visual-ability multiplayer experiences, some of our findings are likely pertinent to other mixed-ability scenarios. In this section, we discuss these implications and opportunities on game design as well as a better understanding of exclusion factors in gaming that must be addressed.

3.3.1 Games designed for one stereotype

Games are typically designed and developed following a user-centered design. Consciously or not, games are framed to a set of abilities. While this perspective can be

[1]Nyctophobia. `https://boardgamegeek.com/boardgame/249505/nyctophobia` (Last visited on October 23rd, 2020)

highly productive to align design choices with game preferences, it severely impedes cross play of individuals with different preferences and abilities. As such, sharing these experiences is unusual among players with different visual abilities. The reality we perceived during the study was participants with visual impairments play a variety of digital games and are pleased with the growth of accessible games. However, the games they play are often specifically designed for gamers with visual impairments or are not popular among sighted people, namely audio games and text-based games. We suspect the same happens in other mixed-ability scenarios (e.g., one-switch games are specifically designed for motor impaired people).

It was stressed by most participants that accessible games are not designed or captivating to sighted players. Participants report that sighted people are keen to try audio games for the first time but quickly lose interest. The disinterest of sighted players is to be expected as accessible games are typically not designed for them. While it may seem counter-intuitive, we argue that in order to ensure inclusive gaming for people with visual impairments, sighted people stereotypical requirements have to be considered. We are not arguing for Universal Accessibility [82], but rather considering sets of stereotypical abilities and design for a broader audience, even if not complete. On the other hand, mixed-visual-ability playful experiences we learned about were, in most cases a situation in which people with visual impairments had to adapt to a game that was not entirely accessible to them. These experiences were associated with unfairness or reduced experience on their part. The lack of intersection between games that sighted people play and games that people with visual impairments play is evident. This leads to the emergence of niche communities that revolve around a common interest, in this case gaming, but are bounded around people's abilities.

Previous studies have shown that visual embellishment does not affect performance but improves player experience [40]. Understandably, it was repeatedly mentioned that audio games do not appeal to sighted people because they need visual interaction to be attracted and to be able to play intuitively. Text-based gameplay was considered "*boring*" to and by sighted people. Participants suggested that an appealing visual component could be given to these games. Some audio games include the use of graphical content, but they are the minority. This concern should not go through just avoiding a black screen, but thinking about the experience through a sighted player's perspective. This burden is, evidently, not in the hands of game developers with visual impairments. It is important to promote the collaboration of designers with different visual abilities in the development of more inclusive games. As much as the particular needs of a population are considered when designing a game, the framing of games should not be exclusive.

In this regard, we must consider that the asymmetry of feedback, with equal goals and functions, could incite the situations of unfairness that participants experience in most mainstream games. Given the relevance many participants give to an even playing ground, we highlight the importance of ensuring that players have access to the same information. This is difficult to balance, especially considering it can be limiting for game design. Work has been done in this regard, with racing games [78] and fighting games [51]. It is important, in future work, to understand how audio games can have complementary visual feedback without offering supplementary information. Also, it is necessary to explore how visual information typically inaccessible in mainstream games, such as health bars and mini maps, can be mapped to auditory interaction without overwhelming the user.

3.3.2 Technology in analog games

In the case of analog games, it is not only a lack of intersection of habits, but actually a lack of accessible games. Participants repeatedly pointed out that adapted versions of tabletop games are scarce and expensive. They emphasize that, being dependent on others to access information and move components, the experience is often diminished and time-consuming. And, again, assistance depends on goodwill, sensibility, and largely on the patience of the person who assists and the one being assisted. For hands-on interaction, many participants say it is frustrating to be constantly knocking the pieces to be able to perceive the game. They often have to trust their memory and, again, other players to know what happened and what is happening.

There are associations dedicated to the adaptation of tabletop games[2 3], as well as games designed with blind players in mind[4 5]. However, there is limited research on how to adapt and design accessible tabletop games. Participants believed that not all games can be adapted, since components can have a lot of text and cannot be efficiently brailled. One respondent suggested that a reasonable solution could be to use QR codes. Some participants reported experiences in which the group excluded them because they do not conform to the use of technology in tabletop games. However, several board games currently make use of applications to enhance the experience [84]. These games, designed from the ground up to accommodate the use of technology, could be an asset for the evolution of mixed-ability gaming. Notably, Johnson and Kane [47] proposed a system to convert board games into more accessible experiences, by augmenting them with on-demand audio descriptions and tactile landmarks. A set of practices for assistive technology in board games has been suggested [72]. Yet, to our knowledge, there is a lack of research work that focuses on exploring different uses of technology in board games and the potential benefits for the inclusion of people with visual impairments.

3.3.3 Unawareness and availability

We noticed some interviewees had difficulty finding accessible games to play, in some cases because they lacked digital literacy or trust to search and install games. Especially in the case of the group interviews with younger participants, we realized there was an atmosphere of unawareness leading to a lack of interest in games. The fact that platforms such as *Steam* and console systems are depicted as inaccessible by participants, may contribute to this problem. If people are limited in ways to access and learn about new games, they are being excluded right from the start. The interviewees who played a greater variety of games mentioned websites through which they kept abreast of new audio games, namely *audiogames.net* and *blindgamers.com*. Diverse websites provide

[2] 64 Oz. Games. `http://www.64ouncegames.com/` (Last visited on May 7th, 2020)

[3] Accessijeux - Jeux de société accessibles aux déficients visuels. `https://www.accessijeux.com/` (Last visited on May 7th, 2020)

[4] Nyctophobia. `https://boardgamegeek.com/boardgame/249505/nyctophobia` (Last visited on October 23rd, 2020)

[5] The Arabian Pots. `https://boardgamegeek.com/boardgame/179956/arabian-pots` (Last visited on October 23rd, 2020)

accessibility reviews of digital games[6][7][8] and tabletop games[9], which are essential for any gamer with disabilities to understand whether the game is accessible and of interest to them. This type of information should be present on mainstream gaming platforms. Also, although these days more video game trailers are released with audio description [69], the dissemination and marketing of new games typically does not offer information about their accessibility. This can be very important for gamers with disabilities to manage their expectations and future acquisitions. An important step may be the adaptation of mainstream platforms and the creation of new digital platforms that facilitate access to games by people with visual impairments.

3.3.4 Untangling synchrony

Synchronous multiplayer gameplay is a challenge in mixed-visual-ability multiplayer experiences. In digital games, participants with visual impairments are unable to keep up with the game when there are many elements on the screen to navigate with assistive technology or to read with low vision. Therefore, among the most realistic perspectives of some participants, there is a desire to see more asynchronous digital games being accessible. Participants say that turn-based and choice-based games can be ideal to be adapted to an accessible format. Given that some games with these characteristics are popular among sighted people [2, 26], this could be a viable way to open doors to the entanglement of gaming experiences between sighted and visually impaired people. One of the respondents demonstrated his desire to play popular Collectible Card Games (CCG), saying that only a few changes would be needed to make them accessible. This facet may also prove relevant in the context of other groups with differing reaction times. As such, novel design strategies are needed to unravel the problem of concurrency in mixed-ability gaming.

3.3.5 Embrancing mixed abilities

An issue that is often discussed is the generated tension between ensuring accessibility and adding complexity to a game [4, 78, 99]. Accessibility, in the absence of clever design, may eventually limit gameplay. As in previous work [4], some interviewees report that many games they try out are too easy or repetitive. Participants mentioned some highly-visual games that they would like to play, but were concerned they would be very difficult to adapt. The approach of adapting games, simply by converting non-accessible information to accessible information is tempting, but it has consequences on the experience [99] — especially, when done *a posteriori* it may have negative consequences. Participants reported that, in most multiplayer games, they are unable to keep up, expressing the feeling of unfairness and diminished experience.

[6]Can I Play That? - For Disabled Gamers, By Disabled Gamers. `https://caniplaythat.com/` (Last visited on October 10th, 2020)

[7]Welcome to Game Accessibility Nexus. `https://www.gameaccessibilitynexus.com/` (Last visited on October 10th, 2020)

[8]DAGER System — Video Game Reviews for the physically disabled. `https://dagersystem.com/` (Last visited on October 10th, 2020)

[9]Meeple Like Us. `https://www.meeplelikeus.co.uk/about-us/` (Last visited on October 10th, 2020)

Accessiblity guidelines are essential to guide game design, however it is inconceivable a set of actionable guidelines that guarantee accessible gameplay, inclusion, and equity in the experience. It was spontaneously suggested by some participants that these tensions may be relieved if the game provides asymmetric interaction. We found reflected on their perspectives, the potential of asymmetry in acknowledging different abilities and enable experiences that challenge and engage each player in different ways. Like asymmetry, we found other design spaces to be explored in future work.

Related work examines mixed-visual-ability collaborative routines in home settings [14] and the office [13]. Similarly, in this study, we learned about practices of sighted and visually impaired people in co-creating accessible gaming. Participants with visual impairments told us about experiences in which they play games indirectly and a sighted player is using the controller (i.e. playing by proxy). In none of these, the perspective is negative, on the contrary, these scenarios are valued as a way of experiencing something that would otherwise be barred. They refer to experiences in which the sighted person controls the game and they make meaningful gameplay or narrative decisions. The feeling of indirect agency could be central in these scenarios, since the ability to affect the game narrative is a critical factor that attract blind people to gaming [4]. Participants point out that these experiences can be enriching for both. While there are no current features that are advertised to support this practice in mainstream games and platforms, there are examples of how features can facilitate this type of gaming experience. For example, the Xbox One Co-Pilot ease of access feature[10] links two controllers to act as one, enabling both players to have an active role. Also, we can envision a service where proxy players serve as a way to interact with the game without actively intervening.

We believe there is room to explore alternative ways of experiencing the games in which, for example, some interaction is reduced to enable the experience. Some participants consider that world-navigation often precludes their participation in many of the mainstream games. It was previously established that in-game navigation is not perceived in the same way by people with different visual abilities and that it is necessary to consider these differences in game design [3, 79]. One of the respondents suggests that it would be innovative if there were alternative mechanics allowing to complete challenges that are not accessible, giving the example of auto-navigation. The recent *The Last Of Us Part II* offers features that simplify (or ultimately automate) parts of the game, such as combat and navigation, in order to enable the experience for people unable to complete these challenges [80]. We argue that adjusting or reducing interaction in a case like this may not necessarily mean reducing the experience. In some cases, it can open up opportunities for other ways to experience the game, for example auto-navigation combined with audio description. Some games offer an alternative gameplay mode in which the player navigates the world with an audio commentary [93]. Evidently, in a scenario where the gameplay is converted into a more static version, the game might come near a cinematic experience. However, it can open doors for people with different abilities to have closer habits and interests. It will be relevant, in future work, to explore alternative ways of experiencing gameplay in designing for inclusive gaming and perceiving the impact on the experience and perceptions of people with disabilities.

[10]Copilot on Xbox One. `https://beta.support.xbox.com/help/account-profile/accessibility/copilot` (Last visited on May 7th, 2020)

3.4 Study Conclusions

In this study, we present a characterization of mixed-visual-ability multiplayer experiences, based on the perspectives of people with visual impairments. While substantial work has been conducted on the topic of game accessibility, this study suggests that there is a lack of intersection in gaming habits of people with different visual abilities. This causes situations of exclusion in group play and gives rise to isolated communities. Most games are designed from a perspective of binary targeting, either targeting sighted people or people with impairments. We emphasize the space that exists to be explored towards more inclusive gaming, more specifically in group gaming experiences with mixed visual abilities. These spaces are born from 1) the need to consider a broader targeting in the design of accessible games and even in games specifically designed for people with disabilities; 2) the potential of using technology in analog games and benefits for people with visual impairments; 3) the inaccessibility of gaming platforms and lack of accessibility information on games available in these platforms; 4) the opportunity in designing games with asynchronous gameplay for mixed-ability gaming, in the sense of designing games that can be enjoyed at the pace of each player; 5) the opportunity to explore alternative ways of experiencing a game and enabling game mechanics, such as auto-navigation in digital games; 6) the opportunity to explore strong asymmetric gameplay in the sense of designing and entwining different interactions and challengers fitting the needs and preferences of each player. It is necessary to explore these design spaces to create experiences that, even if not equal, may be fair, enjoyable and challenging to everyone. In the next chapter, we present our approach and exploration of the latter.

Chapter 4

Instantiating Asymmetric Ability-Based Roles

Following and informed by the aforementioned study, we moved on to reflect and define our approach more concretely. We established points that led the ideation process and the development of two proof-of-concept games:

- **Ability-based**. Challenges are based on what each person can do (visual/auditory challenges). The auditory role is vision-independent — the task is not easier for a sighted person. The auditory role has complementary graphics (important for low vision) but they do not offer an advantage.
- **Complete asymmetry**. Roles intersect in game dynamics (collaboration, communication), but not mechanics — mechanics are radically different.
- **Collaboration**. The cooperation of two or more people is necessary, as one person would not be able to perform all tasks on her own.
- **Interdependence**. Players depend on each other to succeed. Avoid the perception that one person is being "assisted" by another.
- **Agency**. There is decision making on the part of both players. The actions of one influence the other. Avoid the perception that a player is just an "executor" of the game or another player's orders. Avoid the perception that a player is just an "spectator".

In short, we sought to design games in which players have a common goal and collaborate by performing interdependent asymmetric tasks, based on different abilities, challenges and playstyles derived from those. We established it would be pivotal to ensure a balanced asymmetry. Even assuming a radical difference in the agency and in the way of interacting with the scenario and the characters, all players should make decisions and be challenged. Below, we describe our design process and technical aspects of development.

4.1 Design process

We used the aforementioned MDA framework [43] to ideate. Our design process starts with the conception of mechanics mapped to abilities — actions and challenges that depend, for one role on visual abilities and, for the other on auditory abilities. Some of these mechanics were loosely inspired by other video games, audio games and tabletop games that we knew or had already played. We then proceeded to think about how these mechanics could work in the context of a collaborative dynamic between two players, in which player actions are interdependent. The collaborative dynamics of the final games were discussed and iterated several times, also leading to changes in the mechanics associated with each role and the synergies between them. We ended up originating and discussing several ideas for collaborative games with ability-based roles. The choice for the games we developed was influenced by the concern to have simplistic games (that could be played by casual gamers or non-gamers) but that offered challenging tasks, dependent on the communication between the players to promote interaction.

4.1.1 Gameplay delineation

The concept of both games comes from thinking of ways in which both players can move characters in a game scenario. Sonar-like abilities were used before in audio-based world navigation [3, 94]. On the other hand, in video games the character's movement is typically based on the visual identification of obstacles and goals on the screen. We created an interdependence of roles by ensuring that in the games there is only one movable "character/vehicle" and both players are required to successfully maneuver it.

In the first game, the player with visual-based interaction is able to move the character (direct control) and the player with audio-based interaction has a global perception of the scenario (world awareness). The player who moves the character is crucial to achieve the goal, but by limiting the information he has about the scenario, the other player becomes indispensable. With that, we imagined a context in which the two players control a submarine, one of the players has information about the scenario using the sonar (auditory challenge) and the other drives the submarine (visual challenge).

After having the concept of this first game settled, we realized that the roles and dynamics that existed around them could be reversed in a different scenario. We then proceeded to design a second game in which the collaborative dynamics and roles would be similar, but the mapping to abilities is reversed. For this game we created a narrative that involves controlling an aircraft. One player pilots a rescue aircraft through audio-based interaction and the second is an air traffic controller, with a strong visual task. We drew inspiration from how airline pilots typically do not fly based on visual information and have to rely instead on the instruments and instructions of air traffic controllers.

Communication becomes very important between the two players to achieve success. This is the basis of play and collaboration in the game. We ensured that there is considerable diversity in what each player can do (a player could not do all alone). As such, various ability-based mechanics and synergies were designed to fit this collaborative dynamic. Mechanics imply different skills such as memory, dexterity, which could turn to be inaccessible in other contexts of mixed-ability groups. We could

Table 4.1: Roles and mechanics detailed description

/	**Rescue: Under Pressure**	**Rescue: Mayday**
PILOT	**Visual challenge**	**Auditory challenge**
Moves and acts on the character	Drives the submarine; Switches between different modes (Collect, Flare, Shoot and Battery Saving).	Pilots the airplane (auditory compass); Lands and takes off; Switches between airplane and helicopter mode.
Identifies near elements	Spots ores, enemies, blocked passages and the treasure within the light around the submarine; Flares light up the cave.	Audio feedback when the airplane is over rescue spots or under storms; Danger sensor beeps when there's hazards ahead.
Interacts with those elements	Operates mechanical claw to catch ores; Shoots torpedoes to incapacitate monsters and open blocked passages.	Opens floodgates to extinguish fires; Maneuvers the helicopter and operates the rope to rescue people.
Supply resources to the Engineer	Collects ores that are used by the Engineer to charge the battery, upgrades sonar and craft various items.	Answers SOS calls that are redirected to the Enginner (with coordinates and time limit); Regularly reports airplane position.
ENGINEER	**Auditory challenge**	**Visual challenge**
Basic information of the world	Binaural soundscape gives information on the position and proximity of a monster and treasure (passive sonar).	Map screen with control stations marked; Sees airplane position when the Pilot reports its position.
Actively gathers more information	Sends pulses that detect ores, monsters and the treasure with information on their position; Upgrades sonar range.	Marks rescue spots on the map according to coordinates of received SOS calls; Sends pulses to detect storms and other airplanes.
Manages various aspects	Controls battery level (charging it when necessary); Crafts and load items for the Pilot to use (flares and torpedoes).	Watches over the water tank level and the state of the vehicle; Regularly consults the time limits for each task.
Provides verbal guidance to the Pilot	Communicates a direction (e.g., "North"), ensuring the Pilot is able to find ores and the treasure, and to avoid monsters.	Communicates a direction (e.g., "North"), ensuring the Pilot is able to reach rescue spots, and to avoid storms and other planes.

have built the visual role as a mix of visual and hearing challenges (since we did not consider hearing impairments), but we chose to focus the challenges of each role on one sense. We used the word "Pilot" to name the role of the player who has direct control over the character and "Engineer" to name the role of the player who has world awareness. Below we present a characterization of these roles, also detailed on Table 4.1.

4.2 Development

We used Unity[1] to develop the two prototypes. We used the Photon PUN 2+[2] library and cloud service to implement online multiplayer. All graphics and animations are designed from scratch (pixel art) and sound effects are collected from various free sound libraries and post-edited. We made available a version for Windows and a version for OSx. In both games, players can choose to play in one of two languages, Portuguese or English. Speech in both languages was pre-rendered with open-source text-to-speech software and post-edited. The two games were playtested (with sighted-sighted and mixed-ability pairs) and iterated until the final prototype.

Games are not graphically demanding and were optimized to run on low-end computers. They do not offer key remapping, but players who play the auditory role have two control schemes at their disposal, one based on keyboard and mouse and the other keyboard-only. We ensured these two options, since previous studies have shown blind gamers are not used to play with a computer mouse [89, 90]. Both games make use of binaural sounds, but are fully playable through mono audio. We ensured this, inspired by one of the participants in the first study who mentioned that binaural sound mechanics are inaccessible to him, explaining he can only hear from one ear. The way we named the two games does not communicate their special research motivation (i.e. they have no connotations associated with mixed-ability play). We gave them a generic title, which could be the title of any game. We named the first game "Rescue: Under Pressure" (SUB) and the second game "Rescue: Mayday!" (AIR). A trailer video that presents both games is available[3]. Games are also available for download[4].

4.3 Games description

Both games imply a synchronous interaction in which players have to be efficient to achieve the goals within a time limit. Both games include a tutorial mode and a mission mode and require two players — one player creates a private room and the other joins, using the number generated. One player plays as the Pilot and the other as the Engineer. The tutorial guides each player through all available mechanics associated with their role as if they were playing mission mode. The only difference is no time limit to any task, and the prompts to introduce each mechanic gradually. Players have to cooperate to

[1]Unity. https://unity.com/ (Last visited on August 26th, 2020)

[2]Photon PUN 2+. https://assetstore.unity.com/packages/tools/network/photon-pun-2-120838 (Last visited on August 26th, 2020)

[3]Games Trailer: https://youtu.be/Sgxxgt-favA

[4]Games Repository: https://osf.io/2ng3y/?view_only=5ffd259a507b42af946d1468240613bf

fulfill their tasks. In mission mode, there are mechanics that impose time limits to certain tasks, the objectives, resources and challenges are quasirandomly generated (e.g., in SUB ensuring the treasure is at a certain depth). Although the games have a very similar collaborative dynamic, the objectives and the way they manage to achieve them are quite different from game to game [Table 4.1].

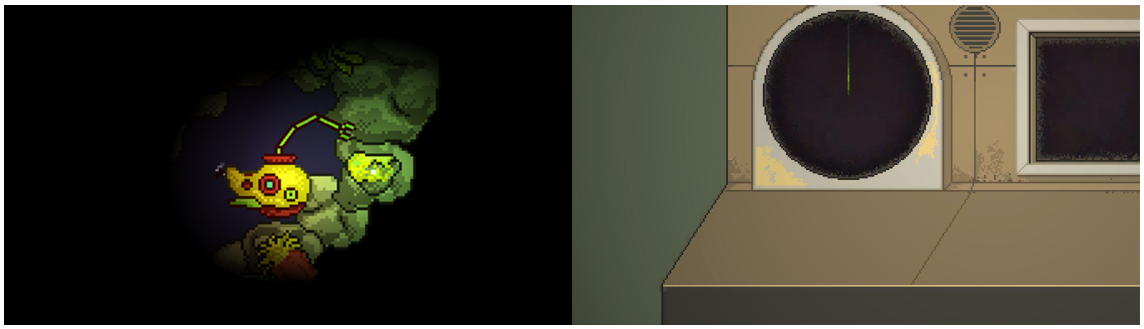

Figure 4.1: Screenshot of Pilot gameplay (left) and Engineer gameplay (right) in Rescue: Under Pressure

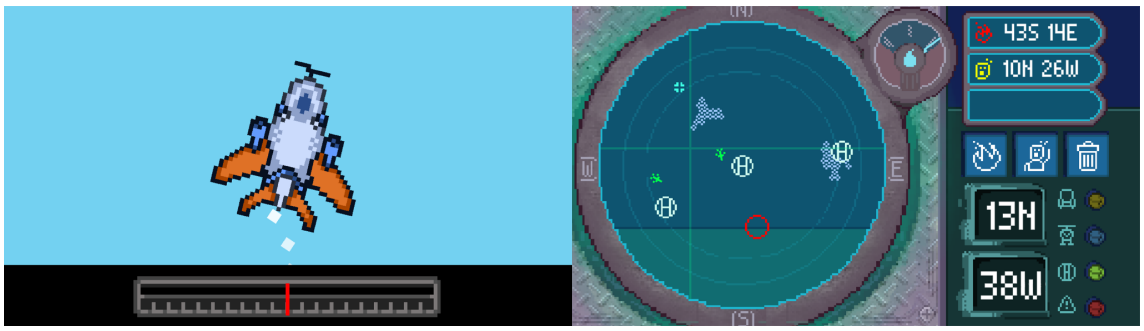

Figure 4.2: Screenshot of Pilot gameplay (left) and Engineer gameplay (right) in Rescue: Mayday!

4.3.1 Rescue: Under Pressure [SUB]

In SUB, two players collaborate to rescue a lost treasure using a submarine. Players lose when battery runs out or if the submarine is devoured by a sea monster.

The Pilot drives the submarine (depending on the Engineer's guidance) and operates various tools. The screen presents a side scrolling view of the ocean, but most of the screen is dark. There's a glow of light around the submarine that allows the Pilot to identify elements just within that spotlight — ores are luminescent, which facilitates their identification [Fig. 4.1]. The Pilot collects ores, depending on the Engineer to manage and use them. The Pilot is also responsible for firing flares, that temporarily light up the cave, and torpedoes to incapacitate monsters and open blocked passages. The Pilot should always ensure the submarine is in battery saving mode when not using tools.

The Engineer operates the sonar and uses resources to craft items and upgrades through an audio interface. On screen is just an image of a control station with various panels [Fig. 4.1]. The Engineer must be always attentive to the soundscape, which gives

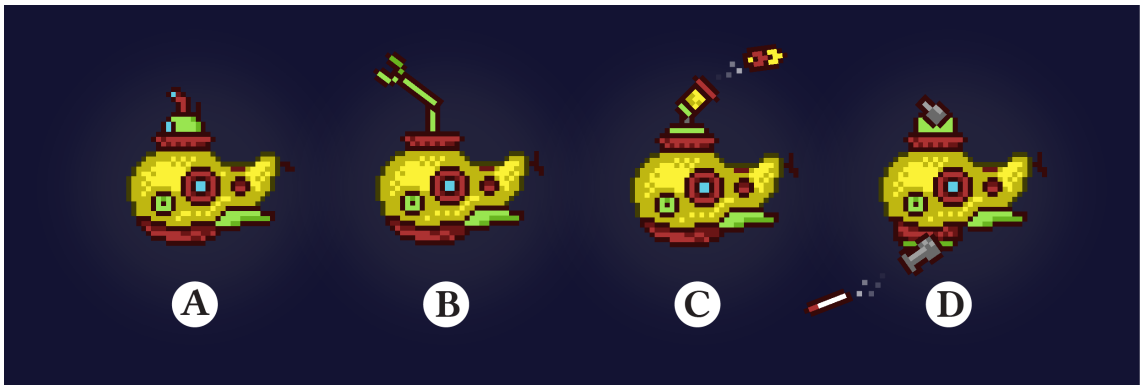

Figure 4.3: The four sub modes in SUB: A – battery saving mode (ensures less battery drain per minute); B – collect mode (the Pilot may extend the mechanical claw to reach minerals on the wall); C – flare mode (the Pilot may rotate the flare cannon and shoot to light up the way); D – torpedo mode (the Pilot may shoot a torpedo from the bottom or top cannon, depending on the mouse position and direction.)

Figure 4.4: The five collectibles in SUB: A – coal ore (used to craft torpedo or charge 10% of battery); B – uranium ore (used to charge 30% of battery); C – quartz ore (used to upgrade sonar range); D – amber ore (used to craft flare); E – treasure chest.

audio feedback when there are monsters or the treasure nearby (passive sonar). Additionally, she actively surveys the submarine surroundings using the sonar in the eight cardinal points (active sonar). Since she will detect various objects, she must establish priorities and guide the Pilot. The Engineer has information about all aspects of the submarine – number of ores, battery level, sonar range, flares and torpedoes (control panel). She is responsible for charging the battery, crafting items (flares and torpedoes), and upgrading sonar range.

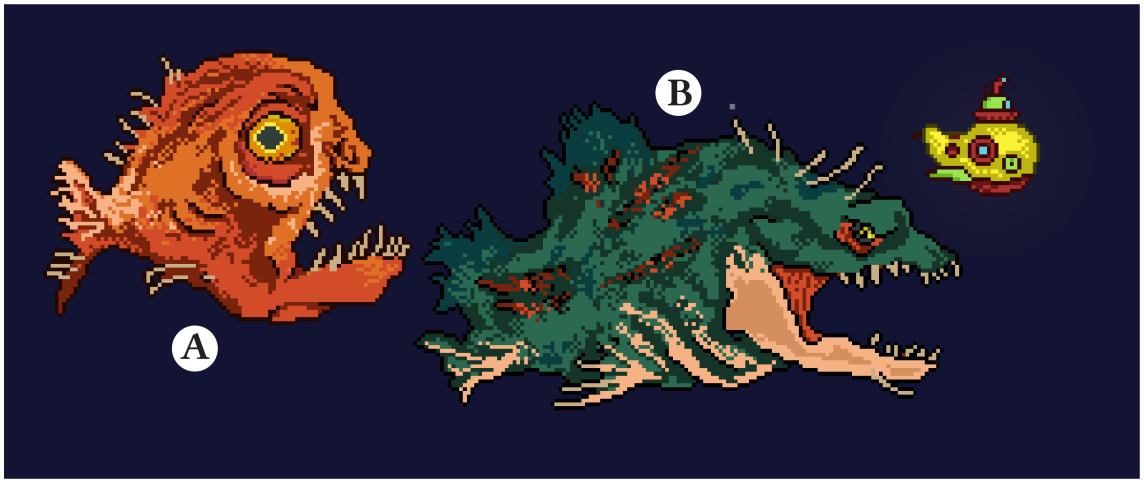

Figure 4.5: The two enemies in SUB: A – giant piraña (slower, deep grunts); B – lizz (faster, reptile roars and hisses.)

4.3.2 Rescue: Mayday [AIR]

In AIR, two players collaborate in air rescue missions with the goal to finish the day without any casualties. Players lose when rescue missions reach a time limit or if aircraft collides with a commercial airplane.

The Pilot lands, takes off and pilots the aircraft, and operates various tools. On screen is the aircraft centered, with a light blue background (or the ground, when landed) [Fig. 4.2]. The Pilot is able to rotate the aircraft to the right or to the left — when aligned with a direction corresponding to a cardinal point, the speaker indicates that cardinal point. To land and rescue people in danger, the Pilot must enter helicopter mode. When receiving a SOS call (only in airplane mode), she must tune the antenna, by searching for the right frequency and redirect it to the Engineer. Relevant elements near the aircraft are highlighted through beeping sensors and audio cues, such as the crackling of flames when over fire sites or lightnings when under a storm. In order to complete rescue tasks, the Pilot must drop water over fire sites and align the rescue rope with people in danger. Lastly, she is responsible for regularly reporting the aircraft position to the Engineer, which will temporarily appear on his map screen (20 seconds cooldown[5]).

The Engineer controls air traffic and marks the location of rescue operations based on received notifications (triggered by the Pilot answering a SOS call). Accordingly, she

[5]The minimum length of time that the player needs to wait after using an ability or item before it can be used again

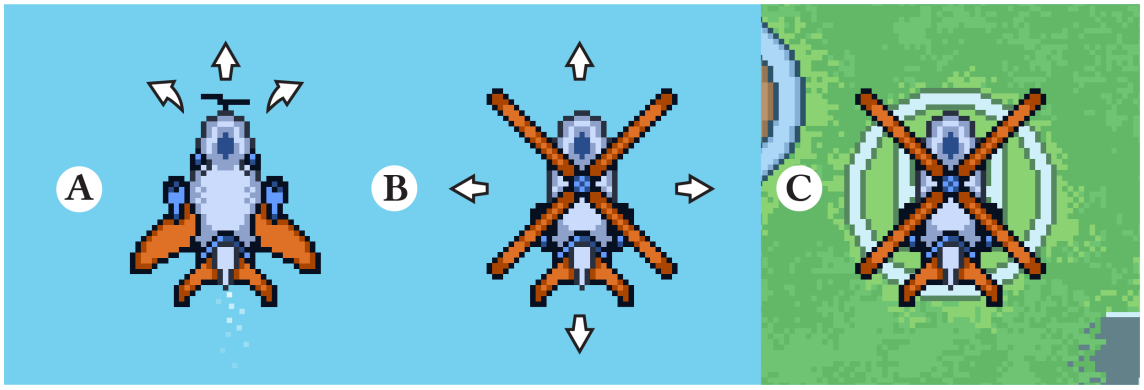

Figure 4.6: The three aircraft modes in AIR: A – airplane mode (the aircraft is always moving forward, the Pilot is able to control its rotation); B – helicopter mode (the aircraft is still, the Pilot is able to move it orthogonally – essential to align the vehicle with a person in danger or with the station when landing); C – landed (the aircraft is still until the Pilot takes off – landing is essential to refill the water tank and to deliver rescued people to the authorities).

Figure 4.7: The panel interface in AIR: A – map screen (on this screen, the Engineer can see the position of the stations and the rescue aircraft — when the Pilot reports its position — detect commercial planes and storms, and mark rescue locations — fires or people in danger; B – coordinate screens (the top screen presents the longitude and the bottom presents the latitude); C – water meter (it indicates the water tank level); D – task feed (where rescue notifications appear, whereas the Pilot answers SOS calls); E – buttons (the left-most and middle button allows the Engineer a rescue location on the map — fires or people in danger, respectively — and the right-most allows her to remove a mark from the map screen); F – state lights (yellow to indicate if there is a rescuee on board, blue to indicate if the aircraft is on helicopter mode, green to indicate if the aircraft is landed, red to indicate if there is an urgent mission — 1 minute left until failure)

must pay attention to the position of rescue locations relative to the aircraft and guide the Pilot by communicating a direction (based on the cardinal points). The screen presents a control station with various panels and buttons, including visual notifications of fires and people in danger — information on coordinates and time limit left until failure[Fig. 4.2]. Similarly to the active sonar, the Engineer sends pulses by clicking on the map and detects hazards, namely storms and commercial airplanes. She has to mentally trace the best routes based on the position of rescue locations and threats. The Engineer also has the task of controlling the water tank level (warning the Pilot to land and refill when needed), vehicle information (e.g., if it is landed, if it is in helicopter mode), and manage the priority of rescue tasks by paying attention to their time limit.

A detailed description of role tasks and mechanics is presented in Table 4.1

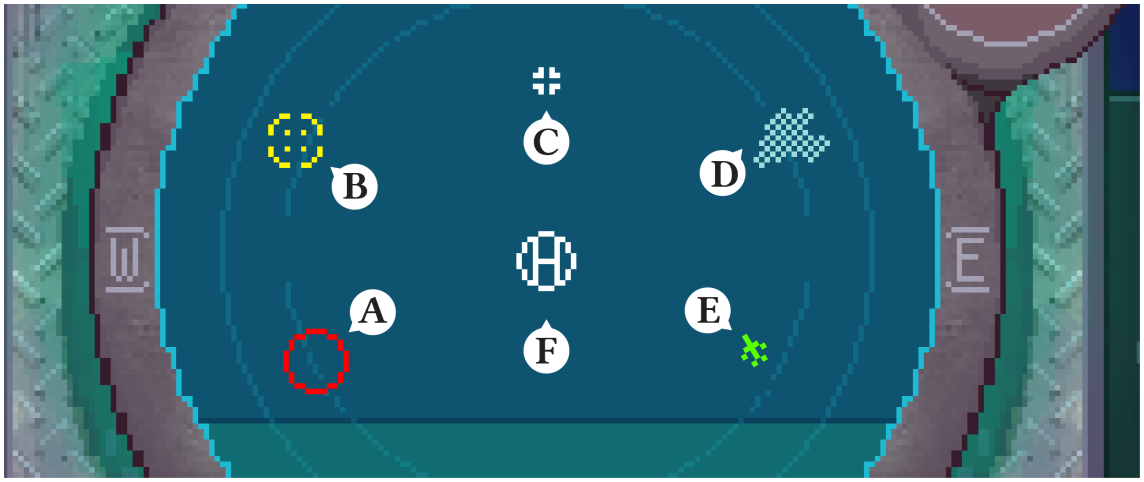

Figure 4.8: The six screen marks in AIR: A – fire site (pinned by the Engineer to signal the position of a fire); B – person mark (pinned by the Engineer to signal the position of a person in danger); C – rescue aircraft symbol (it is temporarily revealed only when the Pilot reports his position; does not provide information about the aircraft's rotation, only its position); D – station mark (there are always three stations distributed across the map during missions); E – storm area (storms move horizontally until they cross the map boundaries and dispawn); F – commercial airplane symbol (commercial airplanes move forward according to their rotation until they cross the map boundaries and dispawn); storm and commercial airplane marks are hidden and are only temporarily revealed when the Engineer launches a scan pulse close to their position on the map.

4.4 Note about COVID-19

The initial plan was to fit participatory design sessions with users into the game development process. However, with the unexpected arrival of the COVID-19 pandemic, we took options that streamlined the work, following safety rules. The final decision was to design and develop the games to an almost final prototype, look for pairs of volunteers (which we reached remotely, including mixed-visual-ability pairs) who were available to try them and iterate with the resulting feedback.

Chapter 5

Inspecting Asymmetry in Mixed-Ability Contexts

We conducted a remote user study with mixed-visual-ability pairs. Our goal was to understand the potential of the approach in creating inclusive and balanced gaming experiences for players with different visual abilities. Our research questions focus on understanding how asymmetric ability-based roles impact players' perceptions. To understand the effects of asymmetry irrespective of type of role played, we developed two games to ensure players could experience both. We also expected gaming preferences (i.e. type of game, type of role) to impact perceptions. Thus, it allowed us to situate players' feedback. Participants completed one questionnaire after playing each game successfully (tutorial + mission). Lastly, participants completed a debriefing questionnaire where we encouraged them to reflect upon the experience. The study was approved by the Ethics Committee of our school.

5.0.1 Participants

We recruited 26 participants, 13 pairs, from 4 countries, aged 16-53 (M=32.31; SD=8.54) [Table 5.1]. We published a call on social networks and other websites related to communities of people with visual impairments, namely Facebook groups, AudioGames forum, mailing lists, etc. We made an effort to recruit people with different gaming experiences by publicizing the call in dedicated gaming forums and institutions' social networks. We reached expert gamers, casual gamers and also people who are not used to play [Table 5.1]. People applied to participate in pairs (one person had to reach out and sent both contacts). One pair element was required to be a screen reader user due to visual impairments (B1-B13) and the other sighted (S1-S13). 8 participants were totally blind (i.e. no light perception) and 5 participants (B2, B4, B6, B7, B8) were near totally blind (i.e. visual acuity lower than 20/1000).

Our main motivation in seeking opportunities for mixed-ability group play lies in enabling friends and family to enjoy gaming together. As such, we recruited pairs of two non-stranger volunteers to assess how asymmetry could be leveraged in mixed-ability scenarios where people were already familiar. Social closeness, competence and autonomy could be affected by other factors among strangers, and are out of the scope.

Participants had to be 12 or older and minors could only participate with the

Table 5.1: Demographic information and gaming frequency of participants (each row represents a pair).

ID	GN	Age	Plays	ID	GN	Age	Plays	Relation	Country
B1	F	34	Daily	**S1**	F	53	Monthly	Friends	Australia
B2	M	28	Monthly	**S2**	F	26	Occasionally	Family	USA
B3	M	41	Daily	**S3**	F	16	Occasionally	Family	UK
B4	M	38	Monthly	**S4**	M	38	Occasionally	Friends	Portugal
B5	F	16	Daily	**S5**	M	18	Weekly	Family	USA
B6	M	32	Occasionally	**S6**	F	27	Occasionally	Partners	Portugal
B7	F	40	Never	**S7**	F	32	Weekly	Friends	Portugal
B8	M	38	Occasionally	**S8**	F	36	Occasionally	Family	Portugal
B9	M	33	Weekly	**S9**	M	31	Monthly	Friends	Portugal
B10	F	41	Never	**S10**	F	38	Occasionally	Friends	Portugal
B11	M	25	Monthly	**S11**	M	26	Weekly	Friends	Portugal
B12	M	37	Never	**S12**	F	37	Daily	Family	Portugal
B13	F	35	Occasionally	**S13**	F	24	Occasionally	Family	Portugal

authorization of the respective legal guardian. Participants should not have other kinds of severe impairments (mobility, hearing, cognitive), since games were not designed considering other disabilities. We compensated all participants who fulfilled the protocol with a €25 (or local currency equivalent) voucher, for their time. Participants who did not comply with the participation terms were also contacted, ensuring we justified why they did not comply and why we could not compensate them monetarily.

5.0.2 Procedure

After filling out the participant form, pairs were contacted via email with instructions and the link to the first game they were required to play. Games were counterbalanced between pairs. Participants had at least one week with the first game and were asked to complete the tutorial (about 20 minutes), and play the mission mode for another 10 minutes. When players failed the mission, they kept trying, until complying with the minimum time. They were given the option to continue playing past the required amount of time. We suggested recording their game session (screen capture + communication audio), but did not make it mandatory. After meeting the requirements, each participant received an email to fill in the questionnaire about the experience (detailed below). Participants were free to continue playing during the week if they wished to. After at least one week, and after completing the experience questionnaire, participants were contacted and given access to the second game (same protocol as described above). After complying with the terms regarding both games, participants had to complete one last online questionnaire about their final thoughts on the approach.

Game sessions of each pair were logged in a database, which was valuable in distinguishing participants' experiences and finding reasons for differences in their perceptions. Whenever they started playing any of the games, they had to identify themselves through their participant ID. We recorded connections and disconnections

from the server, options selected (e.g., control scheme used), game events (e.g., the spawning of a storm) and player actions (e.g., ore collected). Logs also served to verify if the pairs played the required minimum time.

5.0.3 Online Questionnaires

Participants completed four online questionnaires: demographics and gaming habits (Q1), game session (Q2 and Q3) and debriefing (Q4). Q2 and Q3 consisted of the Ubisoft Player Experience Questionnaire (UPEQ) [7] and open ended questions. We adapted three items of UPEQ to instead of referring to "characters" to refer to either "submarine" or "aircraft", according to each game. Additionally, we removed the question *"Other players are friendly towards me"* in the relatedness subscale, as in the context of our study players were not playing with strangers. All of UPEQ 21 items are measured on a 5-point Likert scale, where higher is better. The open questions asked the participants about their experience and thoughts on the roles. Q4 consisted mainly of open-ended questions that probed participants' final thoughts regarding the games and the concept. Questionnaires Q1, Q2/Q3 and Q4 are available in appendices K, L and M.

In all questionnaires, multiple-choice questions were mandatory but open-ended questions were optional. All questionnaires were built in Microsoft Forms, tested for accessibility and were available in two languages, English and Portuguese.

5.0.4 Data analysis

We performed a mixed deductive and inductive thematic analysis over all open-ended questions of the survey, undertaken in line with Braun and Clarke's suggested strategy [16]. We first familiarized with the data, by iteratively reading the answers. Even before we collected the responses from all participants, we started to annotate relevant phrases and recurring ideas in the text. We created an initial set of codes deductively informed by our readings and enriched with the concepts that stem from our research questions (e.g., asymmetry, competence, autonomy, agency). Codes were discussed among the authors, revised and added, as more responses were submitted in multiple sessions. In these sessions, using Zoom shared virtual white board, themes were discussed, codes were aggregated in a shared placed, relationships were identified and discussed with examples (quotes) spread throughout the board that illustrated the themes that led the research team discussions. The final codebook and outline of the themes are available in appendices N and O, respectively.

We used UPEQ to quantitatively measure participants engagement, and analysed its subscales of autonomy and competence ("*each subscale of UPEQ independently predicts measures of engagement in game and are a reliable alternative for direct rating of player experience"* [7]). The quantitative data (responses to the UPEQ scale) are detailed in the appendice P. We performed mixed within-between analysis of variance to assess the effects of *game* and *user group* on UPEQ scores: all reported analysis meet the assumptions of normality, sphericity, homogeneity of variances, and equality of covariance matrices. Two pairs recorded and sent us videos of their sessions, which we reviewed to situate their feedback and illustrate our results.

Using a mixed-method approach, below, we characterize participants' experiences and

Table 5.2: Play session time details; Playtime values represent time to complete the tutorial (T) and time playing mission mode (M) and are always rounded down to minutes.

Pair	SUB Playtime	AIR Playtime
B1 / S1	27 (T) 18 (M)	22 (T) 14 (M)
B2 / S2	18 (T) 11 (M)	20 (T) 31 (M)
B3 / S3	31 (T) 21 (M)	17 (T) 31 (M)
B4 / S4	24 (T) 17 (M)	15 (T) 18 (M)
B5 / S5	15 (T) 38 (M)	16 (T) 15 (M)
B6 / S6	21 (T) 18 (M)	21 (T) 29 (M)
B7 / S7	24 (T) 68 (M)	44 (T) 21 (M)
B8 / S8	21 (T) 20 (M)	41 (T) 19 (M)
B9 / S9	27 (T) 53 (M)	23 (T) 35 (M)
B10 / S10	38 (T) 23 (M)	48 (T) 27 (M)
B11 / S11	23 (T) 11 (M)	26 (T) 19 (M)
B12 / S12	33 (T) 23 (M)	51 (T) 12 (M)
B13 / S13	48 (T) 32 (M)	58 (T) 30 (M)

perspectives on ability-based asymmetric game roles. This characterization is primarily based on the thematic analysis of open ended questions. It is additionally confronted and reinforced by the quantitative data resulting from the administration of UPEQ, game session logs, video recordings, demographics and gaming habits.

5.1 Findings

In SUB, players took an average of 27.4 minutes (SD=1.7) to complete the tutorial and played mission mode for an average of 28.1 minutes (SD=3.2) (over multiple attempts). In 31 attempts, pairs were devoured by a monster and in 14 they ran out of battery. One pair succeeded in the mission. In AIR, players averaged 31.5 minutes (SD=2.9) to complete the tutorial and played mission mode for an average of 23.6 minutes (SD=1.5). None of the pairs was able to successfully complete a mission in AIR, 43 attempts collided with another plane, and 25 were due to the time limits of the rescue operations. 6 played remotely and used audio call to communicate, 6 played co-located and were close enough to communicate, and one pair (B5 and S5) played co-located via audio call. Individual information about each participant's game session is shown in Table 5.2, namely time playing SUB and AIR.

5.1.1 Enabling mixed-ability digital play

Only two sighted participants (S2 and S13) had previously played games with someone with visual impairments (both had played tabletop games with their study partners). Most visually impaired participants reported previous experiences but pointed out that most games do not meet the different needs of groups with mixed visual abilities.

"*There aren't many games that both blind and sighted players want to play*

and can play together because most games are not accessible and sighted people aren't interested in playing poorly designed blindy games." – B1

The lack of options for group play among people with different visual abilities was highlighted. In line with the previous study, participants highlighted the social relevance of gaming.

"*Sometimes people with visual impairments have a hard time integrating. For example, if you are in a group where everyone sees and wishes to play PlayStation, how can you integrate and actively participate in the group? It is important to ensure that people with visual impairments are able to study and work, but it is also important to ensure they are able to have fun. I consider these games to act on that important part of life.*" – S9

The games in the study were portrayed by participants as an exception to the rule. They expressed a sense of gratification for being able to play digital games with friends and family.

"*I haven't been able to find any games that are fun for my brother and I to play together. [...] I feel like it's a great concept and it was a lot of fun being able to play with my brother.*" – B5

"*A great moment of conviviality in which we share an adventure game without limitations. Rare are games in which a person can share a game with a blind person.*" – S9

Participants believed the approach provided an inclusive experience and attributed its cause to the asymmetry of feedback and tasks. Referencing asymmetry as: "*[...] fundamental aspect to allow inclusive fun.*" (B4); "*[...] focused on the best capabilities of each one, games become rewarding for both players*" (S4). One participant highlighted how mixed-ability gaming with balanced roles, as an inclusive experience, can be leveraged for bonding activities.

"*[Mixed-visual ability gaming] inspires bonding between people, trust, team spirit. [...] If there are games with roles for people with visual impairments this can help this integration and equality between partners. I really liked the idea, mainly because the person with visual impairments was not given an easier or less important role, but a role as important as that of the other player.*" – B7

"*Besides strategy, it has a very important message. Integration and we all have an important role, both in the game and in life.*" – S6

5.1.2 Engagement

All participants reported a positive experience with at least one of the games. Regarding overall engagement with SUB, participants reported an average UPEQ score of 3.95 (SD=.08), (visually impaired M=3.89, SD=.48 and sighted M=4.02 SD=.36). In AIR,

participants reported an average UPEQ M=3.65 (SD=.11), (visually impaired M=3.68, SD=.60 and sighted M=3.63 SD=.59). We conducted a mixed within-between analysis of variance to assess the impact of *game* and *user group* on *Overall Engagement*. There was no significant interaction between *user group* and *game*, Wilk's Lambda =.965, F(1, 24)= 8.69, p=.36, partial eta squared = .04. There was a substantial main effect for *game*, Wilks's Lambda = .706, F(1, 24)= 9.99, p=.004, partial eta squared = .29, with both groups showing to be more engaged in SUB. The main effect comparing *user group* was not significant, F(1, 24) = .046, p=.832, partial eta squared = .002.

When we asked participants to choose the game they preferred, 19 participants answered SUB and 5 (one of them sighted) answered AIR. B10 did not answer the question and B3 chose neither, as he states: "*I can't really pick as I enjoyed them equally.*" Overall, the experience with SUB was significantly more engaging for both sighted and visually impaired participants. Particularly, sighted participants highlighted how being the Pilot on SUB was more engaging. S2 commented it was more intuitive and "*more fun and easy to move around*". On the other hand, participants with visual impairments highlighted how immersive was being the Pilot of the aircraft.

> "*I really liked my role. [...] I really like using the different controls to work on the airplane, going where I wanted it as well. I felt like I was actually doing the mission.*" – B5, referring to AIR

> "*I felt at the center of the action! I really felt the adrenaline. [...] I felt the disappointment, when we died or the plane crashed.*" – B11, referring to AIR

In both games, most participants enjoyed the challenge of managing several aspects at the same time, when playing as the Engineer. However, some participants perceived the role as limited, admitting they would like to have more agency in the action (e.g., in shooting monsters, in rescuing people). The preferences of the players stood out in their perspectives, suggesting changes in the controls and tasks of their role, and even giving ideas for other games with asymmetric roles. Particularly, the narrative setting of each game influenced the feelings of each player, both positively and negatively:

> "*I really like the sea. With the sounds and descriptions of my friend, I really imagined the underwater scenery, and that pleased me a lot.*" – B7, referring to SUB

> "*Maybe, airplanes, storms and fires are not something I find particularly nice. [...] Apart from the setting, it was a nice game to play with a blind friend.*" – S2, referring to AIR

B5 mentioned she tried to play text-based games with her brother, but pointed out that, in comparison with these, the games in the study "*were fun because you were actually moving around and doing something*". Audio-based mechanics were praised by participants with visual impairments, such as the helicopter mode ("*I really like the helicopter mode, I want more of that.*" – B2) and active sonar ("*Really interesting concept using sonar to find different types of materials under water.*" – B5).

5.1.3 Competence & Autonomy

Regarding SUB, participants reported an average competence of 3.67 (SD=.46) (visually impaired M=3.65, SD=.44 and sighted M=3.68 SD=.49). In AIR, participants reported an average competence M=3.09 (SD=.98), (visually impaired M=3.22, SD=1.1 and sighted M=2.97 SD=.89).

We conducted a mixed within-between analysis of variance to assess the impact of *game* and *user group* on *Competence*. There was no significant interaction between *user group* and *game*, Wilk's Lambda =.979, F(1, 24)= .524, p=.476, partial eta squared = .02. There was a substantial main effect for *game*, Wilks's Lambda = .719, F(1, 24)= 9.36, p=.005, partial eta squared = .28, with both groups showing to feel more competent in SUB. The main effect comparing *user group* was not significant, F(1, 24) = .204, p=.656, partial eta squared = .008.

Regarding SUB, participants reported an average autonomy score of 3.83 (SD.56), (visually impaired M=3.76, SD=.59 and sighted M=3.89 SD=.54). In AIR, participants reported an average autonomy score of 3.44 (SD=.68), (visually impaired M=3.41, SD=.67 and sighted M=3.47 SD=.72). A mixed within-between analysis of variance showed no significant interaction between *user group* and *game* on *Autonomy* (Wilk's Lambda =.996, F(1, 24)= .105, p=.749, partial eta squared = .004). There was a substantial main effect for *game*, Wilks's Lambda = .701, F(1, 24)= 10.23, p=.004, partial eta squared = .29, with both groups showing to feel more autonomous in SUB. The main effect comparing *user group* was again not significant, F(1, 24) = .224, p=.640, partial eta squared = .009.

Participants pointed out how the games were challenging, with the UPEQ item *"I was good at playing"* having the lowest average score M=2.63. This suggests participants did not feel they had mastered the game in a single play session. As already mentioned, only one of the pairs (B7 and S7) managed to successfully complete a mission, in SUB. They do not play often [Table 5.1], but showed enthusiasm for the game considering the time they played (68 minutes, over 8 attempts) and answers to the survey. In AIR, two pairs were able to accomplish three rescue tasks (they extinguished two fires, rescued a person and landed to deliver the person), but none managed to reach the end of the mission.

Participants felt significantly more autonomous and competent playing SUB. While in SUB, the difficulty level was balanced and related with an engaging experience, participants commented how AIR was too hard and it led to moments of frustration:

> "*There was a need for more hands and eyes in this game. [...] Right now, as it is, the game is frustrating. It leaves the feeling that it is simply impossible to win.*" – B7, referring to AIR

As explained before, in AIR, the Engineer can only see the aircraft's position on the map when the Pilot reports it. We have limited this so that the Pilot can only report his position every 20 seconds. Participants reported the cooldown time was too long, making it difficult to align the aircraft with rescue locations.

> "*Not knowing the plane's position on the map more often induces a very high degree of difficulty that prevents the game from being more engaging.*" – S4, referring to AIR

Participants described how they reflected on the experience and identified points where they could improve as a team. Thus, they mention how their performance in the missions was improved, when adapting new strategies and figuring out how to communicate efficiently. Upon discovering the game, participants ended up sharing the functioning of their role and gameplay. We also observed these interactions and strategy sharing in the videos.

> "*I failed for not giving some important information about sonar, namely how target detection works. I think that if I had given it before, probably the mission's performance would have been better.*" – B11, referring to SUB

In a particular case, which we were able to observe in full through video recording, a pair (B4 and S4) found an unexpected way to achieve an understanding of roles and collaborative dynamics in AIR. S4 was not understanding how the aircraft's navigation worked and was not sure how to give directions. S4 was not understanding how the aircraft's navigation worked and was not sure how to give directions, so the pair decided to reverse roles. Although they were unable to complete the tutorial (the role of Engineer is not accessible to B4), it was enough to reach an understanding and they started to collaborate in harmony. In this case, participants were unable to overcome one of the challenges that the game proposes — reach reconciliation through effective dialogue — and made this curious decision.

The Pilot's dependence on the Engineer was highlighted by some participants. However, as some participants mention, in SUB, the Pilot has more freedom to explore and have a reference of where ores can be, by following the walls.

> "*I found that there is a logical dependence on the Engineer. But there is also always the possibility for the Pilot to find an ore that the Engineer does not immediately find in the sonar. There is a sense of freedom of action.*" – S9, referring to SUB

In fact, unlike the Pilot in AIR, the Pilot in SUB has a visual reference of where important elements may be (an idea of "path", formed by the claustrophobic cave). This provoked a false sense of autonomy, since in both games the Pilot can only perceive elements at a minimum distance and has no way of avoiding dangers without the help of the Engineer.

While the approach was effective in acknowledging and suppressing differences in abilities, other differences had an impact on the experience. For example, B2 played first SUB and explains how the experience has become unbalanced because his partner "was not an experienced gamer, so it was difficult for her to find objects and move around the space". Likewise, after playing Rescue: Mayday!, B2 commented "there's no way I can help the Engineer be better. So if they are struggling and I'm just going in circles, it's not very useful". This happened with other pairs. For example, B1, who plays digital games daily, mentions the role of Engineer in AIR implied a task in which there was "too much to concentrate on for her [partner]".

This was expected, as there is a designed interdependence and both players have to be efficient playing their roles to succeed as a team. Some participants recognized they would have preferred to have more autonomy during the game: "*I wanted to take charge,*

but my role is not one that allows me to take charge." (B2). For some pairs, it is likely that a loosely coupled interdependence would be more appropriate. B2 adds that "*a collaborative game where you're two separate entities, like a wood cutter and a builder, would be better, as then we will be in control of our own section.*".

5.1.4 Equity & Awareness

The collaboration through game roles with tasks and interactions mapped to abilities was associated with social inclusion.

> "*If, on the one hand, a person with visual impairments is more used to explore through hearing, the player without visual impairment can have better perceptions through images. In the end, inclusion and team spirit win, and the barriers between people become more blurred.*" – B6

With UPEQ, we did not find significant interaction between user group and game in engagement, autonomy or competence. Although experiences with the games were different for all pairs, for most, games were successful in creating a space to have fun, irrespective of abilities.

> "*If it was a blind test in which I did not know my partner, I believe I would not realize the other player had a different level of vision than mine. [...] On the other side there was just another player with whom I was having fun, and there was no perception that he was a person with a disability.*" – S4

Games offered different gameplays to each player, which, in this case, allowed for a balanced joint experience. Participants' perceptions illustrate the fact that equality does not mean equity.

> "*It is a good example of how it is possible to create inclusive games, giving players a sense of equal circumstances regardless of their characteristics.*" – B6

Moreover, games showed potential in raising awareness of different abilities, through a social and playful experience. Some participants identified this potential in the games.

> "*There is a lot of prejudice and ignorance in society in relation to what a person with visual impairments can do. This shows that they can perfectly play computer games!*" – B7

> "*It would be a great way of educating sighted people in to what blind people can do in a social non-educational environment.*" – B3

5.1.5 Information asymmetry

Participants enjoyed the natural stimulation of communication and interaction. This was highlighted in both games, since in both the Pilot depends on clear and succinct indications, not being aware of what surrounds him from a distance.

"*I liked the fact that I had poor visibility of the surroundings otherwise I wouldn't have followed as meticulously the Engineer's directions.*" – S2, referring to SUB

S1 comments how the games "*allow team work and [are] a great teacher of proper communication between players.*". Information asymmetry was recognized as the main catalyst of these interactions.

"*The Engineer and I played next to each other. I could see his screen but it didn't give me any clues, which increased the verbal interaction between us. I know the Engineer was notified of the missions being accomplished because he cheered.*" – S2, referring to SUB

While the tight communication was a highlight of the experience for most participants, the repetitive nature of their tasks made communication "boring" for some.

"*I feel like maybe more aspects of the game should be us trying to communicate with each other. Like when I drop the rope, he has to guide it or something. I feel like maybe just telling me where to go all the time could get kind of boring.*" – B5, referring to AIR

All participants played with a constant channel of communication. However, non-spoken forms of communicating were suggested. Namely, forms of communication embedded in the gameplay, such as mechanics that allow the Engineer to give spatial directions without having to speak (e.g., a moving beacon of light). One participant stated that she would also like to have other ways of expressing her emotions during the game in addition to verbal communication: "*It would be nice to have the Engineer sending out a reaction to the Pilot and vice versa, like a high five emoji or something visible/hearable on the screen*" (S2).

Information asymmetry caused tensions between players, as there was an exercise to solve the problem together and establish a consensus. This tension can potentially lead to positive or negative moments. In the case of S6 and B6, the asymmetric experience caused divisive moments.

"*The interaction was not very good because, in the beginning, we were always seeing who was to blame for not being able to achieve the goal. I was saying I was giving the indications of what I was seeing and he was saying he was following the indications he was hearing.*" – S6, referring to AIR

Part of the challenge in both games was to understand the role asymmetry, their own functioning and information. During design phase, we made decisions to keep information asymmetric, in order to stimulate communication. For example, we discussed whether in SUB, the Pilot should have graphical indications of battery level and ammunition. We decided not to, since it is up to the Engineer to control these aspects and to communicate them to the Pilot. Some pairs were successful in finding an efficient way to communicate. As mentioned, one pair was more ingenious and tried to play the tutorial in opposite roles. Participants showed interest in additional ways to have more information about the opposite role: "*Maybe a way to track where the submarine is*

going? It's hard to tell if it's going the right direction. I know that I can always ask, but it would be nice to be able to track it myself as well" (B5). Some highlighted the unity and trust that must exist between the two players to be able to work better as a team.

> "*We had to talk about the point of view and the information that each one of us had about the game, in order to understand, for example, how to escape from the monster. We have to trust our game partner and accept the information he gives us. Therefore, trust, constant interaction and good communication are essential to fulfill the mission.*" – B7, referring to SUB

5.1.6 Balance & Leading perceptions

For most participants, control over the collaboration was balanced and tasks were evenly divided through the two roles. Participants mentioned this in relation to both games, but most admittedly about SUB.

> "*I don't think there was one person who was more in charge. I needed the Pilot to control the submarine, but he needed me to find different objects and monsters, and control the control panel. I like that there wasn't a bigger role.*" – B5, referring to SUB

> "*I really enjoyed the necessary interaction between the two players, which makes them both feel useful. [...] I didn't feel any less important, or with a secondary role because I was a person with visual impairments. On the contrary, I found my role to be important and necessary to the game.*" – B7, referring to SUB

Participants with visual impairments felt their role as the Engineer was essential to the game, highlighting the detection of objects with the active sonar: "The caves were fun to maneuver, and I felt useful with my sonar." (B5, referring to SUB). The collaborative dynamic was also explained as a shift in leadership from one role to another.

> "*I think the Engineer turns out to be a bit of the commander because the Pilot needs his instructions to be able to proceed! But I also think the Pilot, in our case also commanded a little because he was able to understand some things and see that there was something there and ended up moving forward! What is understandable!*" – B11, referring to SUB

In AIR the aircraft is always in motion, the Pilot being able to control its rotation but not its speed. Thus, the communication between players was more intense, when trying to reach the relevant locations. Some participants recognized this, stating that, in this game the Engineer ends up having a more leading role and the Pilot does not have as much freedom to explore.

> "*The Engineer has a more intense command role. The Pilot depends a lot on the Engineer [...] Because sometimes it only takes a few centimeters to reach the target and we do not have a reference to indicate that, precisely.*" – S9, referring to AIR

> "*As a Pilot I was just the performer. Although I gave my inputs, the Engineer had the information. Again, I think the leadership was shared, sort of speak, but the Engineer had more information.*" – B7, referring to AIR

5.1.7 Inherent Inaccessibility of Ability-Based Roles

Some participants commented how they liked to play both roles (Pilot and Engineer) accordingly to the game, and found the ability-based roles to be fundamental for inclusion and equity. However, 3 participants (B1, B2 and B13) mentioned that by having only one accessible role is not very inclusive because the game cannot be played by two visually impaired people. The way we designed the asymmetry fits a very specific scenario: mixed-ability pairs. Some participants mentioned that designing for mixed-ability gaming is "*inherently discriminatory*" (B2). In the case described above, one of the pairs tried to play the tutorial in opposite roles, but were unable to advance because, as expected, the visual tasks were not accessible to the participant with visual impairments. Two participants with visual impairments pointed out that one of the biggest barriers is not having sighted people to play with. It was suggested that games should allow people with visual impairments to play among themselves or even to play alone: "*There should be a way in which we can play alone, so we are not always dependent on the availability of another sighted person to play with us.*" (B13)

5.2 Study Limitations

We conducted a fully remote study with asynchronous communication with participants. As such, we could not control aspects such as the Internet connection of participants, devices they used to play, etc. Although our game prototypes were able to detect disconnections, they were unable to reconnect if the connection was lost for an extended period of time (above 10 seconds). One group unfortunately, was unable to participate due to frequent connection issues.

Another limitation of our prototypes is that they had no audio options. The audio-based gameplay was playtested to fine tune the volume of sound effects. However, audio options are certainly indispensable in any publicly released game. Moreover, participants suggested that games should have a built-in communication system to facilitate distant communication. The narrated interfaces, instructions in the tutorial and various features used during the game were individually recorded with text-to-speech software. However, some participants would prefer the possibility to use their own screen readers with their own defined settings (i.e. speed, tone of voice, etc.).

Some participants with visual impairments reported they found the controls unintuitive, comparing them to the audio games they usually play. In AIR, for example, it was pointed out how navigation through the W, A, S and D keys is not intuitive for someone who is used to arrow keys when navigating in most audio games (in the case of our games, arrow keys were used for other functions). Although we have established two different control schemes, ideally the games should have an option to remap the controls at will for each player.

It is important to note that these games are prototypes, which are probably not at the level of what participants are used to playing. They were developed as proof of concept,

with limited time and resources. None of the games offers new challenges or progression after the first mission (about 15 minutes of play). Although most participants had an engaging experience, it was also associated with tedious moments as the tasks and the way players solved them started to get repetitive.

5.3 Discussion

The experience was seen by most participants as an opportunity in which they shared a playful moment with a family member or friend, with whom they do not usually play. For some participants this was the first experience in which they played with someone with a different level of vision. In the first study, the lack of intersection of gaming habits and communities of people with different visual abilities was highlighted, which is also emphasized in the results of this second study. We collected valuable feedback from participants' perceptions we consider to be informative for research in gaming and accessibility. Some of these observations are mostly related to the nature of collaborative games and asymmetric games, but we focus on issues particularly relevant for mixed-ability gaming contexts.

5.3.1 Inclusive fun through asymmetry

As already mentioned, overall engagement values were significantly higher in one game (SUB) compared to the other. Participants gave reasons for this, importantly the exaggerated difficulty of AIR. Despite the two games being in a prototype phase, according to participants' suggestions, AIR would need new playtesting iterations to improve gameplay aspects and tutorial, and balance the difficulty. However, most participants found both games to be engaging and inclusive experiences. Some pairs ended up playing much more than the minimum times required and would like to have more levels, a greater variety of ores and rescue missions, and ways to customize the submarine.

When it comes to mixed-ability gaming, we argue it is not just a question of people being able to play. The ultimate goal, from a hedonic and social perspective, is to design games that people want to play together. By including two stereotypes in the games through a designed asymmetry, the needs of each player were met. We did not seek for universally accessible gameplay. Rather, we focused design on the individual. It successfully provided an intersection space in which both players felt included, challenged and engaged and in which differences in abilities were not limiting. Moreover, we found for most pairs it successfully provided a balanced collaborative gameplay in which both players felt as valuable contributors. Although the experience was not equal for both, it provided equity.

Notably, the natural incentive for verbal communication, stimulated by the asymmetry of information was highlighted as one of the main factors of fun during the game. In various situations participants tried to help each other to understand the mechanics of the game and planned strategies together. Although the asymmetry of information aroused tension for some pairs, which ultimately led to moments of disagreement, for others it was a challenge of efficient communication and impulsed unity and trust.

Our findings suggest that, in a context of mixed-visual-ability, ability-based roles can create engaging experiences for both players, which answers our first research question. The concept proved to have potential and it should inspire other researchers and game designers to explore alternative approaches to achieve inclusive fun, even if they appear to suffer some shortcomings towards universal accessibility.

5.3.2 Interdependence with ability-based roles

Participants considered the collaboration in both games balanced, in the sense that none of the players was leading or as if the leadership was constantly shifting between the roles as the situation required. Some participants had a perception of a more commanding side, the role of the Engineer being more often referred to as the leading role, for having most of the information. In this regard, comparisons of the two games emerged again. Participants reported that in AIR the Pilot is more dependent on the Engineer. This has evidenced the Pilot's perception of not having reference points to be able to do something. Even though this dependence is also reflected in SUB, players mentioned that, as the Pilot, sighted players had at least a visual reference (cave walls) and ended up having more freedom to explore (by forming a sense of "path").

The asymmetric nature of the information coupled with the interdependence of the roles required participants to: 1) figure out a way to communicate effectively; and 2) trust each other's judgment and information. This led to roles where both players felt valuable, necessary and where the underlying design approach of each role representing an ability did not have any weight to the overall experience, other than guaranteeing an inclusive game. These findings inform how interdependent ability-based roles can impact players' perceived autonomy and competence, which answers our second research question.

There were only brief tasks that players could engage on their own (e.g., collect a found ore, build a torpedo). The tight dependence on each other led some players (particularly when gaming expertise were diverse in the pair) to report a lack of autonomy and wish for overlapping mechanisms, feedback or a different division of tasks. Harris and Hancock [38] have faced this issue when analyzing the impact of different degrees of interdependence on players' perceptions. Their results showed that players felt more connected, engaged and interested when interdependence was tighter. However, similar to what we found, they also showed that less skilled pairs preferred looser interdependence. Harris and Hancock present the concept of rhythm of interdependence, in which the level of dependence between players varies in intensity and dynamics. In the case of our games, we discussed the idea of having moments in which players are independent or can interact asynchronous. For example, having stations where players can craft items, use treasures to buy new abilities, customize the vehicle, etc. We argue that in mixed-ability contexts using asymmetric ability-based roles, there is an opportunity to explore how to guarantee a challenging experience for all players without sacrificing the interdependence and asymmetry that appears to be at the center of both players feeling necessary, competent and trusted. We believe that, for example, by providing difficulty customization within each role it is possible to accommodate players of different expertise levels and maintain high interdependence.

5.3.3 Different-ability awareness

The educational value of games was recognized in raising awareness of the capabilities and gaming habits of people with different abilities. Participants mentioned the experience would be a good way to show how people with visual impairments are playing digital games. Although the games were strictly designed to be for mixed-ability contexts, participants highlighted how even two sighted players with no accessibility awareness could play the game together and be educated of how blind gamers play.

In multiplayer games, players typically have an equivalent general perception of the world and the agents in that world (e.g., in a shooter, one player can see others shooting). In games with complete asymmetry, like ours, players have very different information and this perception is divergent. Participants frequently reported the unawareness of the opposite role (i.e. how it was mechanically and interactively), which in some cases aroused curiosity. This is due to the nature of asymmetric gameplay and the fact that participants could not play in reversed roles (one role is inaccessible). Also, to stimulate communication we made decisions in order to maintain asymmetrical information as much as possible. From players' perspectives, we realized the actions and contributions of each person were for the most part implicit, and had to be communicated verbally. This overall unawareness by design, was associated with "*blurring*" the abilities of each player. In particular, sighted participants mentioned how they would not be able to tell they were playing with a visually impaired player. This provides an opportunity to explore asymmetric games, as a multiplayer entertainment for visually impaired players, where their disabilities do not need to be conveyed or accommodated.

For one pair, asymmetry information gave rise to tension due to the difficulty in finding consensus. However, the same asymmetry inspired the feeling of unity and trust. We find a potential to break stigmas and raise awareness about different abilities. As already mentioned, the individuals who struggled and had to adapt were the ones with less gaming expertise which is expected giving the games were designed to be challenging. We see reflected the potential recognized by Bennett *et al.* [8] of acknowledging the interdependence between people — valuing each person's contributions and destabilizing traditional hierarchies that rank abilities.

> "*Disability awareness as a skill refers to being mindful of the disabilities of people and managing to communicate and work with them effectively.*" [1]

5.3.4 Tensions of Ability-Based Game Design

To minimize the tensions that could arise from having a single role accessible, and the possible connotations with it, we developed two games where a different role was accessible in each. In addition, the two different contexts of play enabled us to explore asymmetric ability-based roles where there is a certain equivalence between the same role in different games.

We acknowledge that having roles inaccessible by design can be controversial, particularly when we consider how difficult it is to get someone sighted to play with, due

[1] `https://www.cleverism.com/skills-and-tools/disability-awareness/` (Last visited on October 13th, 2020)

to the isolated gaming communities. During our recruitment we were contacted by 6 more visually impaired people who wished to participate but did not have any sighted partners they could play with. We argue that the isolated communities and lack of mixed-ability play is a symptom of the lack of balanced and engaging opportunities to play which we address with our approach, by design. Previous work cautioned about the negative effects found in other contexts where there is a separation of technologies [**separate**]. In this study, we found that assuming an explicit asymmetry in gameplay provided an inclusive, engaging and challenging experience for mixed-visual-ability pairs which is not readily available elsewhere.

5.4 Study Conclusions

The games provided a playful intersection space, which stood out in relation to games that participants already played in mixed-visual-ability contexts and provided an exciting experience for those who had never played in such contexts. Ability-based roles entwined in an interdependent collaboration made both players feel as an essential part of the game and differences in abilities did not detract from the experience. Although the approach raised some tensions due to the inherent inaccessibility of one role, it led to joint engaging experiences and feelings of inclusion.

Chapter 6

Conclusions

More than a source of entertainment, playing games has always been a way of socializing. With the advent of digital games, it is nowadays an important social aspect in the lives of many people. While the vast majority of games are designed for the player with no disabilities, it is noticeable how expansive the world of accessible gaming has become. People with disabilities are playing diverse games and are wishing for more accessible content. Unfortunately, research and industry tend to depict accessibility as a way of allowing everyone to experience games, but they typically do not consider scenarios in which people experience them together.

Through a first characterization study (Chapter 3), we gathered informative and inspiring perspectives regarding accessible gaming and mixed-ability experiences. More specifically, we approached 10 blind adults in individual interviews, 10 visually impaired minors and special needs educators through group interviews and people around the world, through two online questionnaires — 140 visually impaired respondents and 17 sighted respondents who had past experiences playing with someone with visual impairments. We outlined two main factors: first, the habits and gaming experiences of people with different visual abilities typically do not intersect, especially at the extremes of visual ability (i.e. sighted people play AAA video games, blind people play audio games); second, although these groups find ways to adapt the games to different needs, gameplay is not designed to fit these needs and, therefore, multiplayer experiences are usually unbalanced and less engaging or unfair for someone. As a result, social barriers between people lead to segregated communities.

This situation must be subverted, with clever design and new approaches. In the second phase of our work, we explore asymmetric games in mixed-visual-ability contexts. Our motivation was to include more than one stereotype (based on abilities — i.e. visual and auditory), by designing two radically different gameplays to fit in the same collaborative game. Following this approach, we designed two testbed multiplayer games (Chapter 4), with asymmetric challenges and controls. In both games, two players collaborate in maneuvering a vehicle, one of them has direct control and interacts with game elements and the other has most of the information about the scenario. The first game is set in the context of an underwater exploration mission (with a submarine) and the second game is set in the context of an air rescue mission (with an aircraft).

Lastly, we evaluated the games with mixed-visual-ability pairs (Chapter 5). We engaged with 13 pairs, who played the games during a period of two weeks and gave

their perspectives through online questionnaires. The data collected and analyzed in the study was comprehensive, namely detailed gameplay logging, video recordings and participants' responses (including the application of a self-perceived player experience scale and open-ended questions). Results showed the approach was able to provide an engaging and inclusive experience unlike the games participants usually play. We were unsure whether the rigid mapping of game mechanics to stereotyped abilities would lead to a negative perception of the roles and games. This was not the case, but tensions arose related to the inherent inaccessibility of one role, more specifically to the fact that two visually impaired people could not play the game.

Despite being controversial, this work shown how assuming asymmetric roles in multiplayer games can entice mixed-ability experiences while maintaining the interest and engagement of players with different needs and preferences. Ultimately, our work shows the potential for novel approaches where equity does not necessarily come from equality. Although we focused on mixed-visual-ability pairs, we believe the approach is promising to different mixed-ability contexts, where roles are designed based on a chosen set of abilities. From the beginning, we never assumed this approach could be a streamlined process that would solve every accessibility problem in digital games. Our motivation was to explore this approach in promoting inclusive gaming and generating new ideas for how to do it.

Accessibility should not be an *a posteriori* effort to adapt something to the needs of people with disabilities. This seems to be recurrent in gaming accessibility. We argue it should be about finding ways to include these different needs from the beginning of the concept and design process. It is essential to think of the population as the complex and diverse compound that it is and to find ways to close the gaps that divide different communities, either because of their abilities, their age, or culture. The more work there is, the more faded the perception that games (and more) have to be done for a single stereotypical player without disabilities and the closer we will be to a world where differences exist and they are proudly embraced by design.

6.1 Future Prospects

The initial characterization study we carried out was very informative and generated several ideas for future work. We believe that mixed-ability gaming is still an underexplored topic where there is a lot of potential. We instantiated our approach in a very specific scenario. Although we consider that our results are pertinent to other mixed-ability scenarios, there is still room to investigate how this approach would manifest, not only in other mixed-ability contexts, but also in other scenarios where players have different gaming habits and preferences, such as in intergenerational experiences. Also, we looked into player collaboration in our approach, but we argue that there is an opportunity to explore asymmetry in competitive gameplay and in team competition.

Fundamentally, we are extremely motivated in exploring the approach and new approaches in the search for games as inclusive social spaces, and we hope this work inspires other researchers and designers along the way. We find rather uncertain how to design gameful activities that foster social connectedness and inclusion in heterogeneous groups. We are interested in identifying factors of exclusion in gaming and particular

cases in which gaming plays and might play an important social role. We are motivated to explore new ideas in the design and development of games that are socially inclusive, promoting the interaction and conviviality of families, school classes and groups of friends, irrespective of mixed abilities or divergent demographics. We are also working on improving the games we developed during this work. Informed by the feedback provided by the participants in the user study, we plan to make an improved version of the games publicly available in the future.

Lastly, we highlight some particular research topics we consider to be relevant in the context of inclusive gaming. Future work should inspect 1) asymmetric gameplay in mixed-ability gaming, considering other abilities (e.g., mixed-motor-ability groups) and/or multiplayer dynamics (e.g., competitive gameplay); 2) asymmetric gameplay in other heterogeneous group contexts (e.g., mixed-aged, mixed-gender groups, such as families); 3) technology that promotes joint experiences in single-player gaming as a way to access inaccessible games (e.g., playing by proxy, shared controls, assistive spectator); 4) technology in analog gaming as an accessibility strategy, and more specifically how to ensure it acts as an element of inclusion that does not become time-consuming or distracting; 5) accessibility information in gaming platforms and news aiming to standardize the way it is presented and generate awareness during the expectation and acquisition of new games.

Appendix A

First Study - Interviews Informative Briefing

We are inviting you to participate in our research study focused on developing accessible games that can be engaging and challenging for players with and without visual impairments.

Before deciding, we would like to introduce you to the details of this research, its motivation, its potential usefulness and the implications of your participation. A member of the research team will accompany you in reading this leaflet and will answer any questions you may have.

1. **What is the study "Games and leisure in the daily life of blind and low vision people"?**

   This study aims to find and evaluate options that can enhance the development of accessible, challenging and engaging games for players with and without disabilities. We focus our research on multiplayer experiences between players with and without visual impairments. This is due to most games being currently based on the ability to visually identify and interact with graphic elements, which ends up hindering the inclusion of blind and low vision players in this scenario.

   Thus, in this study we seek to know the background, the current opinion and the future perspectives on their part, about the act of playing, playing with others and playing collaboratively, as well as about the different approaches in the development of accessible games that emerged over time. As such, we intend to ask you some questions in an interview setting, seeking to better understand your experience in this aspect.

   The information collected will guide the development of an accessible multiplayer game, which can be enjoyed by both sighted players and blind or low vision players. We hope this study will encourage new initiatives by researchers and designers to create inclusive forms of entertainment enjoyed by people with and without disabilities.

2. **Do I have to participate in this study?**

   Participation in the study is completely voluntary. We will describe the study and present the contents of this informative briefing, including the details of your

participation. If you agree to participate, you will sign a Consent Form. Copies of this document and the Informed Consent Form will be provided.

3. **What if I want to give up the study?**

   You are free to give up, at any time, without having to provide any reasons or explanations.

4. **What will I have to do in the context of the study?**

   As part of the study, you will take part in a single session in order to interview you informally on the referred topic — your experience with games and play activities in general. This session will take an estimated time of 40 minutes but does not have a minimum mandatory time.

   The goal of this study is to know and understand what are the games most played by people with visual impairments and why, the genre of games that most attracts your interest today and what aspects could arouse this same interest in the future. It does not aim to evaluate you.

5. **What are the disadvantages and risks of participating?**

   There are no associated risks and the expectation of the research team is the session in which you take part will be a pleasant experience.

6. **What are the possible benefits of participating?**

   According to our experience, people like to take part in studies that promote communication with researchers. Your involvement will help us better understand the preferences and needs of people with visual impairments, taking into account the current entertainment and gaming industry landscape. This study can encourage the growth of accessible games, especially games with a multiplayer component.

7. **What happens when the study ends?**

   Data analysis will end in the last week of December. The study results will potentially be published in academic conferences and journals. If you would like to know details about the results and implications of the study, we will send you a copy of the study report.

8. **What if there is a problem?**

   If you have any concerns about any aspect of this study, you should speak to the responsible investigator, Prof. Tiago Guerreiro, who will do his best to clarify and answer your questions, by phone, 217500566 or email, tjguerreiro@ciencias.ulisboa.pt. If you are unhappy or want to make a formal complaint, you can do so by contacting the Director of the Faculty of Sciences of the University of Lisbon [e-mail: direccao@fc.ul.pt].

9. **Will my information be kept confidential?**

   Yes. We will follow all ethical and legal practices and all information about you will be treated in an absolutely confidential manner. To guarantee anonymity, personal

records will only be available in their entirety, to the responsible researcher, and members of the research team will only have access to the data they need to know. If your data is used for publications or presentations, it will be completely anonymous, without any reference, directly or indirectly, to your identity. If photographs are taken, and it is our intention to use them in any presentation, you will be asked for prior authorization. In the case you authorize the use of photographs or videos, we will first ask you to sign specific consents for that purpose.

10. **Did the study go through a review process?**

    Yes. In fact, this study was reviewed by the Ethics Committee for the Collection and Protection of Science Data (https://ciencias.ulisboa.pt/pt/prote%C3%A7%C3%A3o-de-dados). This committee analyzed the study proposal, as well as all its materials and raised no objections from an ethical point of view.

11. **Who can I contact related to this study?**

    - Prof. Tiago Guerreiro; Faculty of Sciences, University of Lisbon; tjguerreiro@ciencias.ulisboa.pt; 217500566
    - David Gonçalves; Faculty of Sciences, University of Lisbon; davidslycooper@hotmail.com
    - André Rodrigues; Faculty of Sciences, University of Lisbon; andrefprodrigues91@gmail.com

    Feel free to contact them in any matter related to this study. Thank you for taking the time and for considering to take part in this study.

The researchers, Tiago Guerreiro and David Gonçalves

Appendix B

First Study - Questionnaires Informative Briefing

We're inviting you to participate in our research study focused on developing accessible games that can be engaging and challenging for players with and without visual impairments. We seek to better understand the background, current opinion and future perspectives of players who are blind or have low vision about the act of playing and playing with others. Thus, this questionnaire will ask you questions that focus on your experience with different types of games. After completion of this study and subsequent analysis of the data, results will potentially be published in academic conferences and journals, but personal information will remain confidential. We thank you in advance for your interest in participating. Before answering the questionnaire, we ask that you read the terms of participation and confirm your consent to participate. You can withdraw at any time and you will not be required to answer any of the questions. Your participation and responses are completely voluntary. If you have any questions, please contact the responsible investigator, by e-mail tjguerreiro@ciencias.ulisboa.pt.

Thank you for taking the time and for considering to take part in this study.

The researchers, Tiago Guerreiro and David Gonçalves

Appendix C

First Study - Interviews Informed Consent (Adults)

1. I confirm I have read and understood the informative briefing associated with the project.
2. I was given the opportunity to read and consider the information presented, and to ask questions, which were answered satisfactorily.
3. I understand my participation is voluntary and I am free to drop out of the study at any time, without having to give any explanations and without any consequences.
4. I understand the data collected during the study may be known to the members of the research team, whenever necessary for the study. I authorize team members to have access to this data.
5. I understand that, should this investigation be published, all data will be kept anonymous and no information will be identifiable as being mine.
6. I would like the final report of the study to be sent to me. My email address is:
7. I would like to be contacted at the address above about additional sessions or studies related to this study.
8. I declare I have not communicated any potential reasons of any kind that may constitute a risk factor for my health or physical integrity.
9. I declare I participate in this study without any remuneration or compensation, in addition to the reimbursement of expenses incurred.
10. I declare I accept that my interview is recorded in audio.
11. I declare I make my decision entirely freely.
12. I agree to participate in this study.

Appendix D

First Study - Interviews Informed Consent (Minors)

1. I confirm that I have read and understood the information leaflet associated with the project.
2. I understand that my student's participation is voluntary and that he is free to drop out of the study at any time, without having to give any explanations and without any consequences.
3. I understand that the data collected during the study may be known to the members of the research team, whenever necessary for the study. I authorize team members to have access to this data.
4. I understand that, should this investigation be published, all data will be kept anonymous and no information will be identifiable as belonging to my student.
5. I would like the final report of the study to be sent to me. My email address is:
6. I would like to be contacted at the address above about additional sessions or studies related to this study.
7. I declare that I have not communicated any potential reason of any kind that constitutes a possible risk factor for the health or physical integrity of my student.
8. I declare that my student participates in this study without any remuneration or compensation, in addition to the reimbursement of expenses incurred.
9. I declare that I accept that the interview with my student is recorded on audio.
10. I declare that I make my decision entirely freely.
11. I declare that my student agrees to participate in this study.
12. I agree with the participation of my student in this study.

Appendix E

First Study - Interview Script

1. Do you like to play? What do you play?
    - Do you play on the computer? What?
    - Do you play on the phone/tablet? What?
    - Board games/cards/traditional games?
    - Have you tried to play on a console? How was it?
2. What usually motivates you to play?
    - What makes you like a game?
    - What kind of game do you like best? Why?
    - Any type of game you have tried and did not like? Why?
3. Do you play with other people? What?
    - With family/friends?
    - Are there children in your life? How do you play with them?
    - Two ways to play with others — online and in the same physical space. What is your perspective on the two?
    - With other people who are blind or have low vision?
    - How to captivate sighted players and players with visual impairments in the same game?
4. Do you know what collaborative games are?
    - Collaborative games are games in which you and the people who play with you help each other to try to win the game together. A team game, let's say. Do you play or know a game like that?
    - Any collaborative board games?
    - Different characters/tasks (asymmetry)?

5. (Different types of accessible games)

    - Have you ever played a shooting game? What did you think?
    - What about racing games? Do you like them?
    - Rhythm games (games that use music to challenge the player to click the right buttons at the right time). Have you ever played a game like this? What do you think?
    - What about puzzle games? What do you think?
    - Word games, what do you think?
    - Adventure/interactive fiction games (games that use only text — describes the scenario, the events, the characters — the player hears this information and has to make choices that influence the path the story takes). Have you ever played these games?
    - Turn-based games, in other words, games in which a player has as much time as he wants to think, make his move and then passes the turn to the next player. On the other hand, there are games in which all players play at the same time, games with more action. What is your experience and opinion regarding these two different ways of playing?
    - With what do you like to play the most? Mouse? Keyboard? Have you ever used special controllers to play?
    - In some games, objects with a very specific shape are used, or with a special texture that allows them to be identified by touch. This happens more in board games, but in some video games too, where pieces can be detected by cameras. Do you games where this happens?

6. (Other playful experiences)

    - There are accessible ways to experience some museums, the so-called interactive museums. Have you experienced something like this? How was it?
    - And virtual simulators? For example, driving simulators. Have you tried something like this?

7. How do you become aware of new accessible games?

    - Do family/friends recommend you games?
    - Do you usually search for accessible games on the Internet?
    - Games in English/Portuguese?

8. Are there any games you hear about that you would like to play?

    - How could we make this game accessible?
    - Do you feel that the accessibility of some games could be better? In what aspects?

- Do you think accessible games could be more engaging? How?
- What do you have to say about the variety of accessible games?
- What would you like to play with others? Type of game or specific games.

9. Anything else you want to mention, any special experience playing that you haven't told us about?

Appendix F

First Study - Q-VI Questionnaire

Hey there! Thanks in advance for your participation! I'm currently exploring ways to create games that can be enjoyable for players with different levels of vision. My first step is to learn more about group play among people with and without visual impairment. Before proceeding to the questionnaire, I ask that you confirm the participation terms and fill in demographic information.

Section 1

1. I'm 18 or older and I have a visual impairment.
    - Yes, I confirm it
    - No, I don't confirm it
2. I authorize research team members to access the data collected from this questionnaire.
    - Yes, I authorize it
    - No, I don't authorize it
3. Select your gender:
    - Male
    - Female
    - Prefer not to say
4. How old are you?
5. Name the country you're currently living in:
6. What is the higher level of education you have completed?
    - Less than 4th grade
    - 4th grade
    - 9th grade
    - Graduated from high school

- Bachelor's degree
- Master's degree
- PhD degree

7. What's your visual impairment?
    - Mild to moderate low vision (visual acuity between 6/12 and 6/60)
    - Severe low vision to near-total blindness (visual acuity lower than 6/60)
    - Total blindness (no light perception)
    - Other
8. Is the visual impairment congenital? (since birth)
    - Yes, it's congenital
    - No, it's acquired

Section 2

Now, here's a set of questions about your playing experience. The majority of these questions consist on multiple choice. I'd like to hear about your favorite games, how you like to play and who you play with.

1. Why do you play? (you may select multiple answers)
    - To have fun
    - To help me relax
    - To challenge myself
    - To socialise
    - To escape reality
    - To train my mental skills
    - To compete with others
    - Other
2. How often do you play digital games?
    - Daily
    - Several times a week
    - Several times a month
    - Occasionally
    - Never
3. Which platforms do you use to play digital games? (you may select multiple answers)
    - Computer

- Smartphone
- Tablet
- Videogame consoles
- Other

4. Which peripheral devices do you use to play digital games? (you may select multiple answers)
    - Keyboard
    - Standard Mouse
    - Gamepad or handheld controller
    - VR headset (such as Oculus Rift)
    - Braille display
    - Portable magnifier
    - Other
5. Which adaptive software do you use to play digital games? (you may select multiple answers)
    - Screen-reading software
    - Magnification software
    - Dictation software
    - Other
6. How often do you play digital games with other people?
    - Daily
    - Several times a week
    - Several times a month
    - Occasionally
    - Never
7. In which platforms do you play digital games with other people? (you may select multiple answers)
    - Computer
    - Smartphone
    - Tablet
    - Videogame consoles
    - Other
8. How do you play digital games with other people? (you may select multiple answers)

- Online
- In person
- Other

9. With whom do you play digital games? (you may select multiple answers)
    - Family
    - Real-life friends
    - Online friends
    - Strangers
    - Other
10. What barriers do you encounter when playing digital games with other people?
11. List some digital games you play, in order of preference: (you may use commas to separate multiple names)
12. How often do you play tabletop games? (such as cards and board games)
    - Daily
    - Several times a week
    - Several times a month
    - Occasionally
    - Never
13. With whom do you usually play tabletop games? (you may select multiple answers)
    - Family
    - Real-life friends
    - Online friends
    - Strangers
    - Other
14. What barriers do you encounter when playing tabletop games with other people?
15. List tabletop games you play, in order of preference:
16. Do you play with sighted people?
    - Yes, I mainly play with sighted people
    - Yes, but I mainly play with other visually impaired people
    - Yes, I play indistinctly with both sighted and visually impaired people
    - No, I always play with other visually impaired people

17. List games in which you play with other people as a team, known as cooperative games: (optional)

18. Tell us about games or type of games you would like to play: (optional)

19. What more do you want to tell us? (you can use this space to leave any further commentaries about your gaming experience; you can also give us your opinion about this survey, so that we can improve it)

Appendix G

First Study - Q-S Questionnaire

Hey there! And thanks in advance for your participation! I'm currently exploring ways to create games (digital games, tabletop games, toys, etc.) that can be enjoyable for players with different levels of vision. My first step is to learn more about group play among people with and without visual impairment. If you're reading this, you should have a close relationship with someone with a visual impairment. If you have contact with more than one visually impaired person, you should consider the one with whom you have most frequent contact. To make asking questions easier, the name Charlie will be associated with that person. Before proceeding to the questionnaire, I ask that you confirm the participation terms and fill in demographic information.

Section 1

1. I'm 18 or older, I'm sighted and I have a close relationship with someone with a visual impairment.
    - Yes, I confirm it
    - No, I don't confirm it
2. I authorize research team members to access the data collected from this questionnaire.
    - Yes, I authorize it
    - No, I don't authorize it
3. Select your gender:
    - Male
    - Female
    - Prefer not to say
4. How old are you?
5. Name the country you're currently living in:
6. What is the higher level of education you have completed?

- Less than 4th grade
- 4th grade
- 9th grade
- Graduated from high school
- Bachelor's degree
- Master's degree
- PhD degree

7. Select Charlie's gender:
   - Male
   - Female
   - Prefer not to say
8. How old is Charlie?
9. Name the country Charlie currently lives in:
10. What is the higher level of education Charlie have completed?
    - Less than 4th grade
    - 4th grade
    - 9th grade
    - Graduated from high school
    - Bachelor's degree
    - Master's degree
    - PhD degree
    - I don't know
11. Does Charlie understand English?
    - Yes, basic English
    - Yes, advanced English
    - No
12. What's Charlie's visual impairment?
    - Mild to moderate low vision (visual acuity between 6/12 and 6/60)
    - Severe low vision to near-total blindness (visual acuity lower than 6/60)
    - Total blindness (no light perception)
    - Other (Specify)
13. Is Charlie's visual impairment congenital? (since birth)

- Yes, it's congenital
- No, it's acquired
- I don't know

14. How are you related to Charlie? Select the answer that corresponds to your role:

    - Father/mother
    - Grandfather/grandmother
    - Child
    - Grandchild
    - Sibling
    - Partner
    - Other family
    - Teacher
    - Friend
    - Other (Specify)

Section 2

Now, here's a set of questions about Charlie's playing habits and past experiences of you playing with him/her. The majority of these questions consist on multiple choice. I'd like to hear about games/toys you have played and games/toys that you would want to play with Charlie, as well as barriers that you encounter.

1. Which platforms does Charlie use to play digital games? (you may select multiple answers)

    - Computer
    - Smartphone
    - Tablet
    - Videogame consoles
    - Other (Specify)

2. How often do you play digital games with Charlie?

    - Daily
    - Several times a week
    - Several times a month
    - Occasionally
    - Never

3. In which platforms do you play digital games with Charlie? (you may select multiple answers)

- Computer
- Smartphone
- Tablet
- Videogame consoles
- Other (Specify)

4. How do you play digital games with Charlie? (you may select multiple answers)
   - Online
   - In person
   - Other (Specify)
5. What barriers do you encounter when playing digital games with Charlie? (if you don't play digital games with Charlie, what are the barriers that Charlie encounters when playing digital games with others?)
6. Name digital games you've played with Charlie and digital games that you know he/she plays (you may use commas to separate multiple names):
7. Does Charlie play tabletop games? (board and card games)
   - Yes
   - No
   - I don't know
8. How often do you play tabletop games with Charlie?
   - Daily
   - Several times a week
   - Several times a month
   - Occasionally
   - Never
9. What barriers do you encounter when playing tabletop games with Charlie?
10. Name tabletop games or toys you have played with Charlie:
11. Did you ever assist Charlie in playing? How?
12. Name games you would like to play with Charlie:
13. What more do you want to tell us? (you can use this space to leave any further commentaries about your gaming experience with Charlie; you can also give us your opinion about this survey, so that we can improve it)

Appendix H

First Study - Codebook

Table H.1: Characterization Study Codebook (1/4).

Code/Label	Description	Example
1. Game	What is played, how and where it's played.	"*We don't have as much access to games.*"
1.1 Digital	Name or description of a digital game; something particular about digital games.	"*On the computer, I also play cards.*"
1.2 Analog	Name or description of an analog game; something particular about analog games.	"*We also play dominoes.*"
1.3 Playful	Talking games, outdoor games, virtual simulators, other playful activities.	"*I used to play hopscotch.*"
1.4 Platform	Mentions a platform to play video games (e.g. specific consoles, computer, mobile).	"*PlayStation for not having full screen reader support.*"
1.5 Controller	Peripheral device or other input used to play (e.g. reference to a controller).	"*I lose my mouse.*"
1.6 Assistive	Add-on hardware or software used to play (e.g. screen reader).	"*My screen reader does not work to dictate.*"
1.7 Context	Game is played in a specified place or context (e.g. at home with family).	"*Or at the beach, or at home.*"
2. Characteristics	How participants portray the games and experiences mentioned.	
2.1 Accessible	Gameplay or device mentioned as approachable (e.g. "plays well").	"*I play games specifically built to be accessible.*"
2.2 Complex	Game, gameplay or interaction mentioned as complex (e.g. many different controls, intricate narrative).	"*So many controls for so many things.*"
2.3 Simple	Game, gameplay or interaction mentioned as simplistic/casual (e.g. few controls).	"*I try to go for something that's really simple.*"
2.4 Challenging	Game, gameplay or interaction mentioned as challenging or potentially challenging (e.g. "not easy", "player must be fast").	"*That should be more challenging and fun than Nyctophobia.*"
2.5 Diverse	Game or gameplay mentioned as diverse (e.g. sense of progress).	"*Offers so many things to do, even within battle.*"

Table H.2: Characterization Study Codebook (2/4).

Code/Label	**Description**	**Example**
2.6 Slow	Game or gameplay mentioned as slow-paced, too long or repetitive (e.g. text overuse, always the same mechanics).	"*They felt it was too slow.*"
2.7 Engaging	Game, gameplay or interaction mentioned as engaging (e.g. "thrilling").	"*Amazing sound and wonderful gameplay*"
2.8 Adapted	Game is mentioned as an adaptation or as adaptable/non-adaptable; ideas are given about how to adapt some gameplay.	"*Playroom was adapted for blind people.*"
3. Motivation	Why participants play games; why participants want to play games.	"*I want to play with numbers.*"
3.1 Entertain	Plays as a past-time (e.g. when waiting for an appointment).	"This serves as a distraction, entertainment."
3.2 Challenge	Plays for the challenge (e.g. "I like puzzly games", "it's not easy, as such I like it", "I want to show that I can").	"*I like to create challenges around the game.*"
3.3 Socialise	Plays to be with other people.	"*Amazing, we are socialising while playing.*"
3.4 Compete	Plays to compete against other people/AI.	"*I play games to compete.*"
3.5 Relax	Plays to calm down, release stress, escapism.	"*Games relax me.*"
3.6 Learn	Plays to learn new things or skill practice.	"*The essence of gaming is not only on playing, also on learning*"
4. Feedback	How information is conveyed in the game; sensorial stimulation associated with a playful activity.	"*Feedback from the game when each participant needs different information.*"
4.1 Sonification	Mentions the soundscape of a playful activity (e.g. "sounds are great"); gives ideas for sonification-based interaction.	"*Slot machines only use sound effects.*"
4.2 Speech	Mentions the narration or text-reading involved in a digital game; gives ideas for speech-based interaction.	"*Parts are not able to be read out.*"
4.3 Haptic	Mentions haptic interaction in a playful activity; gives ideas for haptic-based interaction; Braille.	"*If a game is not using braille or is not tactile.*"
4.4 Visual	Mentions that the game has/doesn't have visuals; states an opinion about the visual component of a game (e.g. "it would be great if game had visuals", "tiny map").	"*Limited by game types, print sizes, visuals.*"
5. Interaction	Aspects of interaction among players or with AI.	"*It's hard to play with other sighted people.*"
5.1 Competition	Mentions competitive playful interaction.	"*Playing competitively in time sensitive games.*"
5.2 Cooperation	Mentions collaborative/cooperative playful interaction.	"*I love cooperative games.*"

Table H.3: Characterization Study Codebook (3/4).

Code/Label	**Description**	**Example**
5.3 Asymmetry	People have different roles or interact differently with the system; players have complementary information and/or abilities.	"*One game interaction for blind people and one for sighted people.*"
5.4 Together	Other person helps in the playful activity (e.g. playing by proxy); Indirectly plays a game together with another person.	"*A friend or family member wielding the controls on my behalf.*"
5.5 Communication	Mentions the communication occurring in group gaming.	"*Mostly the lack of communication.*"
6. Barrier	What makes gaming difficult/more complicated.	"*Some online audio games require port forwarding.*"
6.1 Unawareness	Unaware of accessible games/controllers or accessibility options in games.	"*There are a lot of visually impaired people who end up not even having a clue what it is.*"
6.2 Disregard	Avoid learning of new games or games that others play; does not explore other games or accessibility options for some reason.	"*I don't even try. I already know, from the start I will not be able to play that.*"
6.3 Expensive	Game or other playful product is mentioned as over expensive.	"*They are much more expensive.*"
6.4 Lack	Game or other playful product is mentioned as currently unavailable or games can't be found when searching (e.g. can't download, few games, little variety); mentions a lack of accessible games in general, games of a certain genre or with a certain theme.	"*Few games are accessible to me.*"
6.5 Inaccessible	Game or interface is mentioned as not accessible (e.g. information is not conveyed at all, not compatible with screen reader, "cannot play").	"*The platform they choose being inaccessible*"
6.6 Cumbersome	Game can be played but it's difficult to access or requires a lot of effort/time to put it to work; gameplay, interaction or device mentioned as cumbersome, confusing or potentially confusing (e.g. "can't understand", "more difficult to use").	"*It's really easy to accidentally knock over pieces*"
6.7 Diminished	It's not fully accessible (e.g. some tasks or minor elements are not accessible, information is not conveyed properly, gameplay is too visual, other people have to help in some tasks).	"*Someone has to help me read the board/cards.*"
6.8 Multiplayer Barrier	What makes multiplayer gaming difficult/more complicated.	"Some communities have been friendlier than others."
6.8.1 Unavailable	Other people are uninterested to play or don't enjoy the game; Person doesn't have people with whom to play.	"Those who are sighted don't want to play games that are blind accessible."

Table H.4: Characterization Study Codebook (4/4).

Code/Label	**Description**	**Example**
6.8.2 Unfairness	Feeling of unfair competition or vain cooperation; mentions that fairness is important when playing with other people.	"*Word indicators are small and makes me feel useless.*"
6.8.3 Exclusion	Other people are playing inaccessible games and person is excluded.	"*The people that I'm playing with kick me out of the game.*"
6.8.4 Playtime	Different game time requirements per play; concurrency of player actions is a problem.	"Not being able to keep up with sighted friends."
6.8.5 Effort	The onus of accessibility is push upon the end-user with disability.	"*It has happened many times that I mark pieces myself.*"
7. Plays With	Experiences playing with someone; something specific about playing with a group of people.	"When playing fifa with others."
7.1 Family	Plays with or against family members; experiences when playing with family.	"Team up with another family member."
7.2 Friends	Plays with or against real-life or online friends; experiences when playing with real-life or online friends.	"I played in a regular weekly tabletop roleplaying session with several friends."
7.3 Strangers	Plays with or against strangers; experiences when playing with online strangers.	"Thus making play with strangers difficult."
7.4 AI	Plays with or against AI bots; experiences when playing with AI bots.	"I play against the computer."
7.5 VI	States that mostly plays with people who have visual impairments.	"I mostly play with other blind and low vision people."
7.6 Sighted	Playful interaction with sighted people; mentions game that plays with sighted people.	"Each team has a sighted player."
8. Desire	Games and genres that participants are interested to play.	
8.1 Desire Game	A game or a genre of games that would like to play; gives an idea for a game; finds something that has potential or is interesting.	"I wish we could play more console RPG and 3D combat games."
8.2 Desire MP	Wants to play that game/playful experience with other people.	"A complex military ship simulation game, with a possible online."
8.3 Mainstream	Wants to play mainstream games.	"I wanted to play it, because everyone else was also playing it."
9. Miscellaneous	Other not-grouped interesting information.	
9.1 Discoverability	Learning about new games (e.g. searching, friends introduce new games).	"Some, I found for myself, by searching on the Internet."
9.2 Lost Gaming	Game or other playful activity experienced before vision loss (doesn't play anymore).	"I then moved to audio games and text games."

Appendix I

First Study - Themes Outline

Table I.1: Characterization Study aggregated themes and descriptions.

Theme	Summary	Informing Codes
Excluded From Play	People with visual impairments are limited in playing with others; Accessible tabletop games are less available and more expensive; Gaming platforms and habits of people with visual impairments differ from sighted people.	Platform, Context, Socialise, Barrier, Plays With, Discoverability, Lost Gaming
The accessibility burden	Gamers with visual impairments often adapt non-accessible tabletop games for themselves; Groups might agree on tweaking rules; Participants end up trying to play inaccessible games.	Adapted, Together, Expensive, Inaccessible, Diminished, Effort, Discoverability
Feedback, fairness and hedonism	Sighted people are not used to audio/text-heavy interfaces and find them complicated and tedious to play; Visual feedback can be important for more inclusive games, but it may give rise to unfairness.	Accessible, Simple, Engaging, Motivation, Feedback, Inaccessible, Unavailable, Unfairness, Plays With
Adaptation trade-offs	Adaptation is limited when the core gameplay is based on visual engagement; Adaptation is limited when the gameplay implies synchronous time-restricted gameplay; *A posteriori* adaptation may have a negative or unforeseen impact on the experience.	Assistive, Complex, Challenging, Engaging, Adapted, Feedback, Cumbersome, Unfairness, Playtime, Desire, Lost Gaming
Assistance and playing together	Depending on the game and/or players, assistance may detract from the experience; Playing a non-accessible game along with a sighted person may be rewarding.	Controller, Context, Interaction, Together, Communication, Inaccessible, Diminished, Sighted
Asymmetric experiences	Taking on different interactions and different challenges for multiplayer gaming can give the the opportunity to cater to mixed abilities; By assuming a strong asymmetric gameplay, each role and challenge can be designed according to the abilities and preferences of each player.	Engaging, Feedback, Interaction, Asymmetry, Unavailable, Unfairness, Playtime, Sighted, Desire

Appendix J

First Study - Quantitative Data

Table J.1: Results from multiple-choice questions in Q-VI (1/2), for all (A) participants, only totally blind (T) participants, only participants with severe visual impairments (S) and with moderate to mild visual impairments (M).

/	A	T	S	M
Participants play digital games...				
Daily	54	30	17	7
Weekly	33	16	12	4
Monthly	17	8	7	1
Occasionally	27	9	12	3
Never	9	4	4	1
Participants play digital games with other people...				
Daily	16	8	6	2
Weekly	26	16	7	2
Monthly	18	8	6	4
Occasionally	35	17	12	4
Never	27	10	14	3
Participants play tabletop games...				
Daily	4	1	2	1
Weekly	16	9	4	3
Monthly	20	10	7	3
Occasionally	70	35	26	8
Never	20	8	10	1
Participants play digital games with...				
Family	42	21	14	6
Real-Life Friends	65	32	24	8
Online Friends	62	37	17	7
Strangers	53	32	14	7
Participants play tabletop games with...				
Family	82	36	33	12
Real-Life Friends	78	38	28	11
Strangers	12	8	2	1

Table J.2: Results from multiple-choice questions (2/2), for all (A) participants (including participants who didn't specify their visual acuity), totally blind (T) participants, participants with severe visual impairments (S) and with moderate to mild visual impairments (M).

/	**A**	**T**	**S**	**M**
Participants play games with...				
Just People With Visual Impairments	7	5	2	0
Mainly People With Visual Impairments	18	11	6	0
Mainly Sighted People	52	16	26	9
Both Equally	46	26	13	7
Participants play digital games on the...				
Computer	89	46	31	9
Tablet	29	11	13	4
Smartphone	87	44	34	7
Console	47	20	17	10
Participants play digital games with other people on the...				
Computer	69	38	22	7
Tablet	13	5	5	2
Smartphone	41	23	13	4
Console	35	17	10	8
Participants play digital games using the...				
Keyboard	94	48	33	10
Mouse	34	9	20	5
Controller	50	20	20	10
VR Headset	5	2	2	1
Braille Display	21	17	4	0
Participants play digital games using...				
TTS Software	97	56	34	4
SST Software	8	4	3	1
Magnifier	10	0	8	2
Magnification Software	24	0	18	6
Translator	1	1	0	0
Participants play digital games...				
Online	85	45	28	10
In Person	48	25	16	7
Participants play games to...				
Have Fun	133	63	51	15
Relax	107	51	41	13
Challenge themselves	92	44	32	13
Socialise	93	45	33	12
Escape	63	29	24	9
Think	65	33	22	9
Compete	65	33	22	7

Appendix K

User Study - Demographics and Gaming Habits Questionnaire

1. Insert your age:
2. Select your gender:
    - Male
    - Female
    - Other
3. Name the country you're currently living in:
4. Select the option that best characterizes your visual acuity in the better-seeing eye:
    - Sighted (visual acuity of 20/20).
    - Mild low vision (between 20/30 and 20/60).
    - Moderate low vision (between 20/70 and 20/160).
    - Severe low vision (between 20/170 and 20/400).
    - Profound low vision (between 20/500 and 20/1000).
    - Near totally blind (lower than 20/1000).
    - Totally blind (no light perception).
5. Do you use any assistive technology? Which ones do you use?
6. How often do you play digital games?
    - Daily.
    - Weekly.
    - Monthly.
    - Occasionally.
    - Never.

7. How often do you play digital games with other people?

    - Daily.
    - Weekly.
    - Monthly.
    - Occasionally.
    - Never.

8. Select the option that best characterizes your biggest motivation to play digital games:

    - Action (Excitement & Destruction).
    - Social (Collaboration & Competition).
    - Mastery (Strategy & Challenge).
    - Achievement (Power & Completion).
    - Creativity (Design & Discovery).
    - Immersion (Story & Fantasy).

9. How are you related to your study partner?

    - Family.
    - Friend.
    - Colleague.
    - Other. (Specify)

Appendix L

User Study - Game Session Questionnaire

1. How did you play the game with your partner?
    - At a distance, through audio call.
    - In the same space, through audio call.
    - In the same space, close enough to communicate.
    - Other. (Specify)
2. For each item, select the option that best characterizes your experience[1]:
    (a) I was free to decide how I wanted to play.
    (b) I could approach the game in my own way.
    (c) The game allowed me to play the way I wanted to.
    (d) I had important decisions to make when playing.
    (e) The choices I made while playing influenced what happened.
    (f) My actions had an impact on the game.
    (g) With time, I became better at playing.
    (h) My gaming abilities have improved since the beginning.
    (i) My mastery of the game improved with practice.
    (j) I was good at playing.
    (k) I felt competent at playing.
    (l) I felt very capable and effective when playing.
    (m) I really like the people I play with.
    (n) I consider players I regularly interact with to be my friends.
    (o) What other players did in the game had an impact on my actions.

[1]For each UPEQ item, participants had to select one option, ranging from “Strongly Disagree” to “Strongly Agree”.

(p) I had to adapt my actions to other players' actions.

(q) I was paying attention to other players' actions.

(r) I felt close to some of the submarine/airplane.

(s) I was bonding with the submarine/airplane.

(t) I cared about what happens to the submarine/airplane.

3. Did you find the game interesting? Why?
4. What would you change about the gameplay?
5. What are your thoughts about the role you played?
6. What did you think of your partner's role?
7. How was player interaction? What could enhance player interaction in this game?
8. Who do you think took charge during the gameplay, if any? Why?
9. Would you recommend this game to anyone? Why?
10. Further comments? Please leave them here.

Appendix M

User Study - Debriefing Questionnaire

1. In which platforms do you usually play digital games?
    - Computer.
    - Mobile devices (smartphone, tablet).
    - Playstation consoles.
    - XBox consoles.
    - Nintendo consoles.
    - Other. (Specify)
2. What kind of digital games do you play the most?
    - Video games.
    - Audio games.
    - Other. (Specify)
3. Name some of your favorite digital games:
4. Which devices do you use to play digital games on the computer?
    - Keyboard.
    - Peripheral mouse.
    - Touchpad.
    - Braille Display.
    - Gamepad/Controller.
    - Headphones/Earphones.
    - Other. (Specify)
5. Which devices did you use to play the two games during the study?
    - Keyboard.

- Peripheral mouse.
- Touchpad.
- Braille Display.
- Gamepad/Controller.
- Headphones/Earphones.
- Other. (Specify)

6. Did you enjoy these experiences? Did you feel your partner was enjoying them? Why?
7. Which game did you like the most? Why?
8. Do you usually play with your partner in this study? Do you play with others who have a different level of vision? What do you usually play with them and what aspects are different in these two games you tried?
9. Do you think this approach, in which players have very different challenges and ways of interacting, has potential for mixed-ability gaming? In what sense?
10. Do you have ideas for other games in which players play different roles (example: Pilot and Engineer)?
11. Further comments? Leave them here!

Appendix N

User Study - Codebook

Table N.1: Characterization Study Codebook (1/3).

Code/Label	Description	Example
1. Game	A game or genre of games is mentioned.	"*Normally I play other team related games.*"
1.1 SUB	Rescue: Under Pressure is mentioned.	"*The submarine game.*"
1.2 AIR	Rescue: Mayday! is mentioned.	"*I liked the second one.*"
1.3 Tutorial	Tutorial mode is mentioned.	"*Tutorial be less speech.*"
1.4 Other	A specific game other than SUB or AIR is mentioned.	"*I play Dungeons and Dragons.*"
2. Role	A game role is mentioned, even from other games.	"*One is the tank, wizard, and healer.*"
2.1 Pilot	Pilot role is mentioned.	"*The Pilot role took charge.*"
2.2 Engineer	Engineer role is mentioned.	"*Actions being performed by the Engineer too.*"
2.3 Auditory	Auditory role is mentioned.	"*The Engineer could hear the position.*"
2.4 Visual	Visual role is mentioned.	"*Being Pilot and seeing the sub move around.*"
3. Comparison	A comparison is made (between games, between roles, between mechanics, etc.)	"*I preferred the setting better.*"
4. Partner	Study partner is mentioned.	"*The engineer and I played next to each other.*"
5. Mechanic	A specific gameplay feature or mechanic is mentioned.	"*I really like the helicopter mode, I want more of that.*"
6. Agency	Agency is discussed (e.g. decision-making or control over the gameplay).	"*I could choose when to say the direction.*"
6.1 Awareness	Agency through world awareness (i.e. sonar, air traffic) is mentioned.	"*Hard as Engineer to try scanning where plane was.*"
6.2 Control	Agency through direct control (i.e. driving, using tools) is mentioned.	"*I was in control of what the plane was doing.*"

Table N.2: Characterization Study Codebook (2/3).

Code/Label	Description	Example
7. Narrative	The narrative setting is highlighted (e.g. underwater scenario, airline operations).	"*I really like the underwater scenario.*"
8. Feedback	Game output is discussed (information given during gameplay).	"*Some way for the Pilot to understand how fast they are going.*"
8.1 Audio	Audio feedback is discussed.	"*Sounds made the goal of the game quite interesting.*"
8.2 Graphic	Visual feedback is discussed.	"*More interesting with the graphics for me.*"
9. Input	Input (controls) is discussed.	"*There was fewer button crunching.*"
10. Competence	Comments regarding competence during game i.e. being (or not) effective in playing the role.	"*Too difficult for someone who's not mathematically minded.*"
11. Autonomy	Comments regarding Autonomy during game i.e. freedom to choose how to play.	"*I'm just going in circles, it's not very useful.*"
12. Connectedness	Comments regarding Connectedness during game i.e. closeness to partner.	"*It was a lot of fun being able to play with my brother.*"
13. Competition	Competitive gaming is mentioned.	"*You are on a team and need to beat another team.*"
14. Collaboration	The collaboration and/or its synergies are highlighted.	"*Teamwork makes the game even more attractive.*"
14.1 Interdependence	The interdependent collaboration is highlighted.	"*I had poor visibility of the surroundings otherwise I wouldn't have followed as meticulously the engineer's directions.*"
15. Leading	A leading role is discussed (control over the collaboration).	"*I felt like I had more control as the Pilot.*"
16. Balance	Comments on perceptions of balance (e.g. of tasks, of roles).	"*I felt the game was more balanced than the sub game.*"
17. Asymmetry	The asymmetric tasks and/or interactions are highlighted.	"*Able to use sound when my brother couldn't see.*"
18. Communication	Communication during gameplay is mentioned; New ways of communicating are suggested.	"*Would be nice to have the Engineer sending out a reaction to the Pilot.*"
19. Ability	Player abilities are mentioned.	"*Take advantage of their best senses.*"
20. Expertise	Gaming expertise/skills of players are discussed.	"*It was too expansive and for an inexperienced player.*"
21. Difficulty	Participant mentions game difficulty.	"*Scale the challenges.*"
21.1 Onboarding	Participants comment on the difficulty to understand rules.	"*It was easier to understand.*"
21.2 Gameplay	Participants comment on the difficulty to win the game.	"*High degree of difficulty.*"

Table N.3: Characterization Study Codebook (3/3).

Code/Label	Description	Example
22. Complexity	Game complexity is discussed.	"*Other levels of complexity.*"
22.1 Simple	Game or mechanic is mentioned as simplistic; Desires of more variety.	"*I would also add in different kinds of rescue missions.*"
22.2 Complex	Game or mechanic is mentioned as complex.	"*Initially the game looks complex and with a lot of instructions.*"
23. Reaction	A reaction to something is described.	"*Highly stressful.*"
23.1 Boring	Something is highlighted as tedious.	"*Could get kind of boring.*"
23.2 Frustrating	Something is highlighted as frustrating.	"*First game caused few frustrations.*"
23.3 Engaging	Something is highlighted as engaging.	"*I really enjoyed playing.*"
23.4 Confusing	Something is highlighted as confusing.	"*I was kind of confused.*"
23.5 Interesting	Something is highlighted as interesting/attention grabbing.	"*Really interesting concept using sonar.*"
24. Exclusive	Game or experience is regarded as exclusive.	"*It isn't very inclusive to have only one role be accessible.*"
25. Universal	It is mentioned that both roles should be accessible.	"*People with any level of vision should be able to play any role.*"
26. Inclusive	Game or experience is regarded as inclusive.	"*Giving players a sense of equal circumstances.*"
27. Mixed-ability	Describes a past experience of mixed-ability gaming.	"*I play Dungeons and Dragons with a mixed group of blind and sighted players.*"
28. Educational	Potential for educational purposes is recognized.	"*It is an important skill to learn.*"
29. Barrier	It is mentioned something that prevents from playing the games or playing in general.	"*My problem is the lack of time to play.*"
29.1 Bug	A bug or technical problem with a game is reported.	"*The messages around uranium were buggy, I believe.*"
29.2 Unavailable	It is mentioned there's no one to play with.	"*It's difficult to find a sighted person to play with.*"
30. Suggestion	A suggestion is given.	"*A voice chat service built into the game would be great*"

Appendix O

User Study - Themes Outline

Table O.1: User Study aggregated themes and descriptions.

Theme	Summary	Informing Codes
Enabling mixed-ability digital play	The games provided a playful intersection space, which stood out in relation to games that participants already played.	Partner, Connectedness, Asymmetry, Ability, Exclusive, Universal, Inclusive, Mixed-ability, Barrier, Unavailable
Engagement	At least one of the games was engaging for participants and factors such as the preferences of each player, immersion and the narrative setting had influence on overall engagement.	Game, SUB, AIR, Role, Pilot, Engineer, Auditory, Visual, Comparison, Mechanic, Connectedness, Asymmetry, Difficulty, Gameplay, Reaction, Boring, Frustrating, Engaging, Interesting, Narrative, Feedback, Audio, Graphic
Competence & Autonomy	Both games were challenging and players had to be efficient and reach conciliation to succeed as a team. For some pairs, differences in game expertise led to a desire for looser interdependence and more agency in the gameplay.	Game, SUB, AIR, Role, Pilot, Engineer, Auditory, Visual, Comparison, Agency, Awareness, Control, Competence, Autonomy, Collaboration, Interdependence, Leading, Balance, Expertise, Difficulty, Onboarding, Gameplay, Complexity, Simple, Complex, Reaction, Frustrating, Confusing, Input, Barrier, Bug
Equity & Awareness	Both parts felt as an essential part of the game and differences in abilities did not detract from the experience. Collaboration was balanced for most pairs.	Role, Pilot, Engineer, Agency, Collaboration, Interdependence, Leading, Balance, Asymmetry, Ability, Expertise, Feedback, Audio, Graphic, Inclusive, Mixed-ability, Educational
Information asymmetry	Asymmetry information stimulated tight communication between players and other ways of interacting were suggested.	Role, Pilot, Engineer, Auditory, Visual, Partner, Agency, Awareness, Control, Autonomy, Connectedness, Collaboration, Interdependence, Balance, Asymmetry, Communication, Feedback, Audio, Graphic
Inherent Inaccessibility of Ability-Based Roles	Having an inaccessible role is not inclusive, as two players with visual impairments would not be able to play together.	Role, Asymmetry, Ability, Exclusive, Universal, Barrier, Unavailable

Appendix P

User Study - Quantitative Data

Table P.1: Responses to UPEQ scale (you may consult appendix L for the list of items), after playing Rescue: Under Pressure (SUB). Values range from "Strongly Disagree" (1) to "Strongly Agree" (5).

ID	a)	b)	c)	d)	e)	f)	g)	h)	i)	j)	k)	l)	m)	n)	o)	p)	q)	r)	s)	t)
B1	2	2	4	4	4	4	4	3	4	3	3	3	4	4	4	4	4	3	3	3
S1	3	4	4	4	4	5	5	4	4	4	4	3	5	5	5	4	5	4	4	5
B2	5	3	3	4	5	5	5	5	5	1	1	3	5	3	5	5	5	4	3	1
S2	2	2	2	4	5	5	4	4	4	3	4	3	5	5	5	5	5	4	3	4
B3	4	4	4	5	5	5	5	4	4	4	4	2	5	2	5	5	5	4	4	5
S3	4	4	3	4	4	4	3	4	4	3	3	2	4	4	4	4	4	4	4	4
B4	5	5	2	1	1	3	5	2	5	3	4	4	5	5	1	1	3	5	5	3
S4	3	4	4	4	4	4	4	5	5	2	2	4	4	5	5	5	5	5	5	5
B5	4	4	4	4	5	5	4	4	4	2	4	5	5	4	5	4	5	4	4	5
S5	4	5	4	5	5	5	4	4	4	3	4	4	4	4	5	4	5	4	3	4
B6	4	3	3	3	4	4	4	4	4	3	3	3	4	4	4	4	4	4	4	4
S6	4	4	2	4	4	4	3	4	3	3	3	4	4	3	5	5	5	4	4	5
B7	1	2	2	4	4	4	5	5	5	3	3	4	5	5	5	5	5	4	4	5
S7	5	5	2	2	2	4	5	5	5	3	2	2	5	5	5	5	5	3	2	5
B8	1	4	4	4	4	4	4	4	4	3	3	3	5	4	4	3	4	4	4	4
S8	5	4	4	4	4	4	5	4	4	4	5	4	4	4	4	4	4	4	4	4
B9	5	1	4	5	4	5	4	5	5	3	3	4	5	5	5	3	5	5	5	4
S9	3	3	3	5	5	5	3	4	3	2	3	3	5	5	4	4	5	4	5	5
B10	3	3	3	3	3	4	4	3	4	2	2	2	4	2	3	2	4	2	2	2
S10	4	2	2	2	4	4	4	4	4	2	2	2	5	2	5	4	4	4	4	4
B11	4	4	5	4	3	4	4	4	4	3	3	4	5	5	4	5	5	5	5	5
S11	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5
B12	4	4	4	5	5	4	3	4	4	2	2	4	5	5	4	4	5	4	4	4
S12	4	4	2	4	4	4	4	3	4	3	3	4	4	4	4	4	4	4	4	4
B13	3	4	4	5	5	5	5	5	5	4	4	4	5	5	5	5	5	5	5	5
S13	4	4	4	4	5	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4

Table P.2: Responses to UPEQ scale (you may consult appendix L for the list of items), after playing Rescue: Mayday (AIR). Values range from "Strongly Disagree" (1) to "Strongly Agree" (5).

ID	a)	b)	c)	d)	e)	f)	g)	h)	i)	j)	k)	l)	m)	n)	o)	p)	q)	r)	s)	t)
B1	2	2	3	4	5	5	3	2	3	3	2	1	4	4	5	4	4	2	2	3
S1	2	2	2	4	2	3	4	4	2	2	2	2	5	5	4	4	4	2	2	4
B2	5	3	3	4	5	5	4	4	4	1	1	2	5	5	5	5	4	3	3	4
S2	2	2	2	4	4	4	4	4	4	3	3	3	3	4	4	4	4	4	3	3
B3	3	4	5	5	5	5	2	2	2	2	2	1	5	2	5	5	5	4	4	5
S3	4	2	3	4	4	4	2	3	2	2	3	4	5	4	4	4	4	4	4	4
B4	5	4	4	1	1	3	5	4	5	3	5	4	5	5	5	4	5	5	5	5
S4	3	4	4	4	4	4	5	5	4	2	3	3	4	5	5	5	4	5	4	4
B5	4	2	4	2	4	5	5	4	5	5	5	5	5	5	5	4	5	4	5	5
S5	4	4	3	4	4	5	5	5	4	2	4	3	5	4	5	5	5	4	3	4
B6	4	3	3	4	4	4	4	4	4	2	2	2	5	4	4	4	4	4	4	4
S6	2	2	2	5	4	4	2	2	2	2	2	2	4	3	4	4	4	5	5	5
B7	1	1	1	4	4	4	2	2	2	1	1	1	5	5	4	4	4	1	1	4
S7	5	3	1	5	4	5	2	2	2	1	1	1	5	5	4	5	5	3	4	5
B8	5	5	4	4	4	4	3	4	4	3	3	3	5	4	4	4	4	4	4	4
S8	5	4	3	4	4	5	4	4	4	2	3	2	4	4	4	5	5	4	4	4
B9	1	1	4	2	4	5	4	4	4	3	4	3	5	5	5	4	5	5	5	4
S9	2	2	3	5	3	4	3	3	4	1	2	1	5	5	5	5	5	3	4	5
B10	2	2	2	3	3	3	3	3	3	1	1	2	4	3	2	2	2	2	2	4
S10	2	2	2	2	4	2	3	3	3	1	1	1	4	3	4	4	4	2	2	2
B11	3	3	4	5	4	4	4	4	4	4	4	5	5	5	5	5	4	4	4	5
S11	5	5	5	5	5	5	5	5	5	4	4	4	5	5	5	5	5	5	5	5
B12	1	2	2	4	4	5	5	5	5	4	4	4	5	5	5	4	4	5	4	5
S12	4	3	2	4	4	5	5	5	5	3	3	3	5	5	5	5	5	5	4	5
B13	1	2	2	4	4	5	5	5	5	2	2	2	5	5	5	5	5	4	4	5
S13	2	2	2	4	4	4	3	3	4	2	2	3	4	5	4	4	4	4	3	4

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